S
622.33
M26 wcf
1983
U01.1

FINAL COMPREHENSIVE Environmental Impact Study

PLEASE RETURN

STATE DOCUMENTS COLLECTION

SEP 19 1983

MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

Western Energy Company's Rosebud Mine

AUG 29 1984

Montana State Library
3 0864 1006 6174 6

DEPARTMENT OF STATE LANDS

TED SCHWINDEN, GOVERNOR

CAPITOL STATION

STATE OF MONTANA

(406) 449-2074
(406) 449-4560 RECLAMATION DIVISION

1625 ELEVENTH AVENUE
HELENA, MONTANA 59620

(406) 449-2711 EIS TEAM

1539 ELEVENTH AVENUE
HELENA, MONTANA 59620

Erratum

Reference: Final Comprehensive Environmental Impact Study, Western Energy Company's Rosebud Mine. Prepared by MDSL and U.S. Office of Surface Mining. July 1983.

Reader Note: The Rosebud Mine Comprehensive Study was in error: The Rosebud Mine would raise TDS levels in the East Fork Armells Creek alluvium to 3,000 or 4,000 mg/l rather than 4,000 or 6,000 mg/l as stated in the final Comprehensive Study. Therefore, on page 3-50, the third complete paragraph should read as follows (underlining denotes change in paragraph):

Continued mining of the East Fork Armells Creek drainage area upstream from Colstrip will increase TDS levels of the alluvial water to above pre-mining levels. Premining TDS levels are generally less than 2,500 mg/l upstream from Colstrip but mining would raise TDS levels to 3,000 or 4,000 mg/l, a 20 to 60 percent increase. Some areas immediately adjacent to mine areas may exceed 4,000 mg/l but mixing and dilution within a mile or so of spoil inflow areas would generally return TDS concentrations to 3,000 or 4,000 mg/l. (See water use.)

AN EQUAL OPPORTUNITY EMPLOYER

Digitized by the Internet Archive
in 2014

https://archive.org/details/westernenergyco1983mont_1

FINAL COMPREHENSIVE ENVIRONMENTAL IMPACT STUDY

WESTERN ENERGY COMPANY'S ROSEBUD MINE

OSM 83-10

Prepared by

Montana Department of State Lands
and
U. S. Office of Surface Mining

Dennis Hemmer, Commissioner
Montana Department of States Lands

Allen D. Klein, Administrator
Western Technical Center
U. S. Office of Surface Mining

JULY 1983

Reader Note

This document was published in March 1983 as a Draft Comprehensive Environmental Impact Statement (DEIS). Since then the U.S. Environmental Protection Agency has determined that, because the DEIS does not include a "no action" alternative, and does not precede a specific agency decision, the document does not meet the technical requirements of an EIS, as defined by the National Environmental Policy Act (NEPA) of 1969.

Therefore, the document has been retitled as the "Comprehensive Environmental Impact Study."

Despite EPA's determination and the title change, the public review process required by both NEPA and MEPA were followed in preparing this Final Environmental Impact Study. The analysis contained in this report will be used as a reference for future Environmental Impact Statements on the Rosebud Mine.

SUMMARY

( ) Draft (X) Final Environmental Impact Study

Montana Department of State Lands
U.S. Office of Surface Mining

TYPE OF ACTION

Western Energy Company has submitted a comprehensive mine plan representing existing and planned surface coal mining operations at the Rosebud Mine. The plan was not submitted as a formal application for a mine permit. The Department of the Interior and the Montana Department of State Lands have prepared numerous environmental impact statements (EIS's) on specific areas within the Rosebud Mine in the past. To date, no comprehensive assessment of the environmental impacts of mining operations at the Rosebud Mine has been done. This comprehensive study will provide the Commissioner of the Montana Department of State Lands and the Secretary of the Interior with a reference document for the entire Rosebud Mine to serve as the framework of subsequent EIS's prepared to analyze environmental impacts from site-specific activities related to 5-year permit applications, thereby minimizing duplication and overlap. The comprehensive study does not serve as a decision document but provides the information necessary to facilitate and improve the decisionmaking process.

BRIEF DESCRIPTION OF THE ROSEBUD MINE

The Rosebud Mine is located in Rosebud County near Colstrip, Montana. The mine extends immediately from town for approximately 8 miles southwest, 5 miles southeast and 4 miles northeast. The mine has been divided into Areas A, B, C, D, E and Pit 6. Parts of Areas B, C, and E are presently permitted.

SUMMARY OF IMPACTS BY DISCIPLINE

Geology - Geologic impacts would be minor. In all areas to be mined, stratigraphy would be disrupted by removal of the Rosebud coal, and the lower quality McKay and Stocker coal seams would become uneconomic to recover. The topography would become smoother and slightly lower. In some areas minor gullying, settlement, or piping might occur. Overburden mixing would slightly decrease electrical conductivity in near-surface material and might locally increase overburden chemical components commonly found in deeper, undisturbed layers.

Hydrology - Groundwater aquifers would be disrupted by mining and replaced with spoils that would have flow characteristics similar to the original aquifers. During mining in each area, the flow of groundwater would be

intercepted by the pits. Groundwater discharging to the pit would be at a maximum immediately after the pit is opened and would diminish with time. Water levels in the replaced spoils would eventually reach pre-mining levels.

The reestablished spoils aquifer would have approximately twice the concentration of total dissolved solids of the pre-mine Rosebud coal and overburden aquifers. Spoils water flow would follow the regional south eastern flow direction, eventually reaching Cow Creek and East Fork Armells Creek. Spoils water discharging at the boundaries of the mined areas to streams could have an appreciable effect on surface water quality during low flow. In addition, groundwater in undisturbed valley fill along the East Fork of Armells Creek and Cow Creek would gradually be displaced by spoils water, increasing the concentration of total dissolved solids. The quality of water in aquifers underlying the Rosebud coal, however, would not be appreciably affected by mining or replacement of spoils.

Seepage from the existing and proposed mine areas and industrial ponds will continue to affect surface- and groundwater quality and quantity near Colstrip. Increases in salinity and alluvial groundwater could have detrimental impacts on Cow Creek and East Fork Armells Creek. In the long term, vegetative communities in the bottom of these creeks around Colstrip may change in response to fluctuations in water levels and increased dissolved solids.

The probable impacts to the surface water hydrology over time would include a decrease in the total volume of runoff from the mined areas, a reduction of peak flow magnitudes, and the near-total removal of sediment from water introduced to the streams from the mined areas, all due to the placement of sediment ponds. Sediment ponds may also cause an episode of high erosion upon removal, although these episodes would be localized and insignificant.

Climate - Mining would have no impact on the climate of the area.

Air Quality - The levels of fugitive dust in the Colstrip area would not change significantly due to mining; however, areas having increased dust emissions would shift: dust levels would decrease in Areas E and B and increase in Areas A, C and D. Because of the large size of the dust particles, little impact to human health is expected. The reduction in visibility due to dust levels would be minor.

Noise - Noise from the mine would reach an increasingly larger area. Noise in quiet areas away from Colstrip would probably increase as a result of more frequent coal shipments and additional blasting. Sound levels within Colstrip would not increase dramatically, because sound levels are already high.

Soils - Soils of the areas to be mined would become mixed and their chemical and physical properties would be partly altered. Soil mixing and the

loss of discrete soil types would reduce the post-mining potential for crop production, especially in Area C. The potential for successful establishment of warm-season grasses and ponderosa pine, especially in Area D, would also be lowered due to soil mixing. Soil availability may be limited in Area A and in the northern half of Area D. For all disturbed soils, bulk densities of soils could increase; organic matter would decrease; and nutrient cycling in the soil would take a number of years to reach equilibrium.

Vegetation - Impacts to vegetation would include the temporary disruption of vegetative cover on areas as they are prepared for mining. Reestablished vegetation would be dominated by cool-season grasses and legumes, representing a probable reduction in seasonal diversity from the pre-mined vegetation. Cropland and pasture areas would be replaced with native grasses and legumes. Areas with a high proportion of conifer forest types would also be replaced with native grasses and legumes. Some loss of riparian habitats may occur, especially where East Fork Armells Creek is to be mined. It is likely that warm-season grasses would decrease in post-mined areas, and shrub cover would also decrease. The regrading and revegetation of old spoils remaining from operations in Areas D and E will bring land back into rangeland production that previously had limited usefulness.

Wildlife - Wildlife habitats would be temporarily destroyed by mining. Some of these habitats, due to the altered character of the reclaimed area, would not be replaced. One golden eagle nest, one prairie falcon nest, and four sharp-tailed grouse dancing grounds would be disturbed by mining, and successful reestablishment is uncertain. Riparian areas along East Fork Armells Creek will be disrupted, although no regional population impacts are expected to occur.

The significant reduction of ponderosa pine and shrub habitat proposed in the reclamation plans will reduce the potential area for deer and pronghorn antelope wintering and will change the species composition of small mammal and songbird populations. These, in turn, may affect predators. Waterfowl, reptiles, amphibians, and fish would not be significantly affected.

Sociology and Economics - The population of Rosebud County (9,899) is expected to increase by about 61 percent between 1980 and 2010. Nearly 11 percent of that increase will result from the Rosebud Mine. The largest expected increases will begin in the mid-1990's. Much of that increase will be in Colstrip. The percentage of the county's total population resulting from the Rosebud Mine will vary from a high of 14 percent in 1990 to 10 percent in 2010. Per capita income is expected to increase. The proposed developments will also contribute to additional urbanization. Social and community services will be affected, and several capital improvement projects will be required. Both local revenues and operating expenditures are expected to increase.

Land Use - Mining would alter 16,000 acres of land. Following currently proposed reclamation plans, 1,691 acres of cropland and 1,626 acres of pon-

derosa pine would not be restored. Mining activities would result in the short-term cessation of grazing; however, productivity of the areas after reclamation is expected to be higher than pre-mine levels, though possibly less than the pre-mine potential. The use of the conveyor system from Area C will result in a longer period of reduced production from the alfalfa field within the railroad loop crossed by the conveyor.

Transportation - Proposed development would cause an increase in road use, due to increased commuter traffic, and in rail use, due to increased coal production and transportation.

Recreation - Recreation resources in Colstrip and Rosebud Counties are not currently sufficient to meet the projected recreational requirements as population increases. Long-term recreational needs within Colstrip should be met by the additions proposed in Colstrip's master plan. Nonurban recreational resources that could be adversely affected would be the availability of deer populations for hunting.

Cultural Resources - Sixty-nine cultural resource sites lie within the mine area, and 57 of these would probably be destroyed or directly affected under current plans. Forty-one sites lie in the buffer zone; 16 of these could be indirectly affected by blasting.

Seven of the sites within the mining areas have been determined eligible for the National Register of Historic Places and an additional 50 sites appear to be eligible. Four sites within the buffer zone area have been determined eligible and an additional four appear to be eligible for the National Register.

Esthetics - The landscape would change in color, contrast, and texture due to the reduction or loss of ponderosa pine, shrub areas, and sandstone outcrops, none of which are unusual for the region.

RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY.

The proposed mine areas would produce a total of 376.7 million tons of Rosebud coal: 185 million tons from Area C would serve as the sole source of fuel for Colstrip Generating Units 3 and 4. Coal from Areas A and B would be sold to utilities in the upper Midwest, and coal from Areas E and D are dedicated to the Corette Generating Plant in Billings, Montana, and to Colstrip Generating Units 1 and 2.

Mining in Area E is projected for completion in 1984, Areas A and B in 1994, and Area D in 2004. Mining in Area C would be completed by 2017. If the areas were not disturbed, they would continue to produce livestock forage, wildlife habitat, winter wheat, hay, marginal forest products, and scenery. All of these uses would be curtailed during mining, and crop pro-

duction, timber production, wildlife habitat, and scenic value would be reduced after reclamation. Compared to pre-mining conditions, productivity for livestock grazing would increase; however, the potential productivity of the post-mined areas would be lower than the pre-mining potential, primarily due to soil mixing.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The mine plan for each area assumes that only the coal from the Rosebud seam would be mined, leaving behind the lower quality coal contained in the McKay and Stocker seams. After mining of the Rosebud seam is completed, it is unlikely that the coal of the McKay and Stocker seams could be economically mined.

The existing stratigraphy in the mine areas would be permanently altered, and rock outcrops currently found in the areas would be removed, eliminating at least one site for a golden eagle nest. The existing topography would be altered, and mixing of overburden would alter the character and land use potential of the reclaimed surface. Successful establishment of conifers or shrubs is uncertain, and the potential for crop or timber production would be reduced. Vegetative diversity may also be reduced. Four sharptail grouse dancing sites and numerous cultural resource sites would be removed or disturbed.

TABLE OF CONTENTS

	Page
SUMMARY	v
INTRODUCTION	0-1
SECTION 1.0 DESCRIPTION OF THE PROPOSAL UNDER CONSIDERATION	1-1
1.1 MINE HISTORY	1-1
1.2 THE ROSEBUD MINE TODAY	1-1
1.2.1 Mine Schedule	1-1
1.2.2 Coal Reserves and Production	1-1
1.2.3 Employment at the Mine	1-5
1.3 MINING PLAN	1-5
1.3.1 Facilities	1-5
1.3.2 Mining Method	1-9
1.4 RECLAMATION PLAN	1-9
SECTION 2.0 DESCRIPTION OF THE EXISTING ENVIRONMENT	2-1
2.1 GEOLOGY	2-1
2.1.1 Topography/Geomorphology	2-1
2.1.2 Stratigraphy	2-4
2.1.3 Overburden	2-4
2.1.4 Aquifers	2-5
2.1.5 Structure	2-5
2.1.6 Geologic Hazards	2-8
2.1.7 Paleontology	2-8
2.1.8 Resources	2-8
2.2 HYDROLOGY	2-10
2.2.1 Groundwater	2-10
2.2.1.1 Water-bearing Strata	2-10
2.2.1.1.1 Rosebud Spoils	2-13
2.2.1.1.2 Valley Fill Material	2-13
2.2.1.1.3 Rosebud Coal Overburden	2-15
2.2.1.1.4 Rosebud Coal	2-15
2.2.1.1.5 Rosebud/McKay Interburden	2-17
2.2.1.1.6 McKay Coal	2-17
2.2.1.1.7 Sub-McKay	2-18
2.2.1.2 Groundwater Flow	2-18
2.2.1.2.1 Nature of Flow Within Water-Bearing Strata	2-19
2.2.1.2.2 Aquifer Communication	2-26
2.2.1.2.3 Groundwater Recharge-Discharge	2-26
2.2.1.2.4 Groundwater-Surface Water Relationships	2-30
2.2.1.2.5 Subirrigation	2-30
2.2.1.3 Groundwater Quality	2-33
2.2.1.3.1 Water Quality Suitability	2-33
2.2.1.3.2 Aquifer Water Quality	2-37
2.2.1.4 Groundwater Use	2-40

TABLE OF CONTENTS
(Continued)

Page

2.2.2 Surface Water 2-41
2.2.2.1 Drainage Network Characteristics 2-41
2.2.2.2 Stream Channel Characteristics 2-43
2.2.2.3 Drainage Basin Sediment Yields* and Landscape Stability 2-43
2.2.2.4 Surface Water Flows 2-44
2.2.2.5 Surface Water Quality 2-49
2.2.2.5.1 Streams 2-49
2.2.2.5.2 Ponds 2-53
2.2.2.5.3 Springs 2-53
2.2.2.6 Surface Water Use 2-54

HYDROLOGY GLOSSARY 2-55

2.3 CLIMATE 2-59
2.3.1 Temperature 2-59
2.3.2 Humidity 2-59
2.3.3 Precipitation 2-59
2.3.4 Severe Weather 2-59
2.3.5 Evaporation 2-60
2.3.6 Dispersion Meteorology 2-60
2.4 AIR QUALITY 2-63
2.4.1 Ambient Air Quality Standards 2-63
2.4.2 Total Suspended Particulates 2-63
2.4.3 Settled Particulates 2-67
2.4.4 Visibility 2-67
2.5 NOISE 2-68
2.6 SOILS 2-70
2.6.1 Area A 2-72
2.6.2 Area B 2-72
2.6.3 Area C 2-74
2.6.4 Area D 2-77
2.6.5 Area E 2-79
2.6.6 Conveyor Corridor 2-79
2.7 VEGETATION 2-81
2.7.1 Range Condition and Stocking Rates 2-84
2.7.2 Threatened and Endangered Species 2-85
2.8 WILDLIFE 2-86
2.8.1 Big Game 2-87
2.8.1.1 Pronghorn 2-87
2.8.1.2 Mule Deer 2-89
2.8.1.3 Other Big Game Animals 2-89
2.8.2 Other Mammals 2-89
2.8.3 Mammalian Predators 2-93
2.8.4 Upland Game Birds 2-93
2.8.5 Waterfowl 2-96
2.8.6 Songbirds 2-96
2.8.7 Raptors 2-98
2.8.8 Reptiles and Amphibians 2-99

TABLE OF CONTENTS
(Continued)

Page

2.8.9 Fish..... 2-99
2.8.10 Threatened and Endangered Species..... 2-100
2.9 SOCIOLOGY AND ECONOMICS..... 2-101
2.9.1 Economic/Demographic Conditions..... 2-101
2.9.1.1 Economic Conditions..... 2-101
2.9.1.1.1 Personal Income..... 2-101
2.9.1.1.2 Employment..... 2-102
2.9.1.1.3 Retail Trade..... 2-102
2.9.1.2 Demographic Conditions..... 2-105
2.9.1.3 Baseline Economic/Demographic Forecast..... 2-106
2.9.2 Social Life..... 2-108
2.9.2.1 History..... 2-108
2.9.2.2 Social Structure..... 2-108
2.9.2.3 Values..... 2-109
2.9.2.4 Other Concerns..... 2-109
2.9.2.5 Social Indicators..... 2-109
2.9.2.5.1 Selected Vital Statistics..... 2-109
2.9.2.5.2 Social Problems..... 2-110
2.9.2.5.3 Participation in Public Welfare Programs..... 2-111
2.9.3 Social and Community Services..... 2-112
2.9.3.1 Law Enforcement..... 2-112
2.9.3.2 Fire Protection..... 2-112
2.9.3.3 Sanitary Sewer..... 2-113
2.9.3.4 Water Supply..... 2-113
2.9.3.5 Solid Waste..... 2-113
2.9.3.6 Social Welfare..... 2-114
2.9.3.7 Medical Services..... 2-114
2.9.3.8 General Government..... 2-116
2.9.3.9 Library..... 2-116
2.9.3.10 Housing..... 2-116
2.9.3.10.1 Rosebud County..... 2-116
2.9.3.10.2 Colstrip..... 2-117
2.9.3.10.3 Forsyth..... 2.118
2.9.3.11 Education..... 2-118
2.9.3.12 Northern Cheyenne Reservation..... 2-120
2.9.3.12.1 Tribal Government..... 2-120
2.9.3.12.2 Law Enforcement..... 2-121
2.9.3.12.3 Health Services..... 2-121
2.9.3.12.4 Water Supply..... 2-121
2.9.3.12.5 Waste Disposal Systems..... 2-122
2.9.3.12.6 Fire Protection..... 2-122
2.9.3.12.7 Education..... 2-122
2.9.4 Public Finance..... 2-123
2.9.4.1 Historical Conditions..... 2-123
2.9.4.1.1 Montana Coal Board..... 2-124
2.9.4.2 Baseline Fiscal Projections..... 2-126
2.9.4.2.1 Rosebud County..... 2-126
2.9.4.2.2 Town of Forsyth..... 2-127

TABLE OF CONTENTS
(Continued)

Page

2.9.4.2.3 Forsyth School District..... 2-128
2.9.4.2.4 Colstrip School District..... 2-128
2.9.4.2.5 Town of Colstrip..... 2-129
2.10 LAND USE..... 2-130
2.10.1 Regional Land Use Patterns..... 2-130
2.10.2 Local Land Use Patterns..... 2-130
2.10.2.1 Area A..... 2-133
2.10.2.2 Area B..... 2-133
2.10.2.3 Area C..... 2-133
2.10.2.4 Area D..... 2-133
2.10.2.5 Area E..... 2-134
2.10.2.6 Conveyor Corridor..... 2-134
2.10.3 Federal Planning..... 2-134
2.10.4 Local Land Use Planning..... 2-134
2.11 TRANSPORATION..... 2-135
2.11.1 Roads and Highways..... 2-135
2.11.2 Railroads..... 2-135
2.11.3 Other Networks..... 2-138
2.12 RECREATION..... 2-139
2.12.1 Urban Recreation Resources..... 2-139
2.12.2 Nonurban Recreation Resources..... 2-139
2.13 CULTURAL RESOURCES..... 2-142
2.14 ESTHETICS..... 2-162

SECTION 3.0 ANALYSIS OF IMPACTS..... 3-1

3.1 GEOLOGY..... 3-1
3.1.1 Topography/Geomorphology..... 3-1
3.1.2 Stratigraphy..... 3-1
3.1.3 Overburden..... 3-1
3.1.4 Structure and Paleontology..... 3-5
3.1.5 Geologic Hazards..... 3-5
3.1.6 Resources..... 3-6
3.1.7 Mitigation..... 3-6
3.2 HYDROLOGY..... 3-7
3.2.1 Groundwater..... 3-7
3.2.1.1 Impacts through 1987..... 3-7
3.2.1.1.1 Groundwater Flow..... 3-7
3.2.1.1.2 Groundwater Quality..... 3-15
3.2.1.1.3 Water Use..... 3-20
3.2.1.2 Impacts in the Rosebud Mine Area through the Life of the Mine and 100 Years Beyond... 3-23
3.2.1.2.1 Groundwater Flow..... 3-23
3.2.1.2.2 Groundwater Quality..... 3-31
3.2.1.2.3 Water Use..... 3-32
3.2.2 Surface Water..... 3-32
3.2.2.1 Impacts through 1987..... 3-32
3.2.2.1.1 Drainage Basin Characteristics... 3-32
3.2.2.1.2 Stream Channel Characteristics... 3-32

TABLE OF CONTENTS
(Continued)

Page

3.2.2.1.3 Basin Sediment Yields and Geomorphic Stability..... 3-33
3.2.2.1.4 Flow Rate Analysis..... 3-33
3.2.2.1.5 Water Use..... 3-34
3.2.2.1.6 Water Quality..... 3-34
3.2.2.2 Impacts through the Life of the Mine and 100 Years Beyond..... 3-34
3.2.2.2.1 Drainage Basin Characteristics... 3-34
3.2.2.2.2 Stream Channel Characteristics... 3-35
3.2.2.2.3 Basin Sediment Yields..... 3-35
3.2.2.2.4 Flow Rate Analysis..... 3-39
3.2.2.2.5 Water Use..... 3-39
3.2.2.2.6 Water Quality..... 3-41
3.2.3 Cumulative Hydrologic Impacts..... 3-42
3.2.3.1 Groundwater..... 3-42
3.2.3.1.1 Impacts through 1987..... 3-43
3.2.3.1.1.1 Groundwater Flow.... 3-43
3.2.3.1.1.2 Groundwater Quality. 3-45
3.2.3.1.1.3 Groundwater Use..... 3-47
3.2.3.1.2 Impacts through Life of Mine and 100 Years Beyond..... 3-48
3.2.3.1.2.1 Groundwater Flow.... 3-48
3.2.3.1.2.2 Groundwater Quality. 3-49
3.2.3.1.2.3 Groundwater Use..... 3-51
3.2.3.2 Surface Water..... 3-52
3.2.3.2.1 Impacts through 1987..... 3-53
3.2.3.2.1.1 Surface Water Flow.. 3-53
3.2.3.2.1.2 Surface Water Quality..... 3-53
3.2.3.2.1.3 Surface Water Use... 3-53
3.2.3.2.2 Surface Water Impacts through Life of Mine and 100 Years Beyond..... 3-54
3.2.3.2.2.1 Surface Water Flow.. 3-54
3.2.3.2.2.2 Surface Water Quality..... 3-54
3.2.3.2.2.3 Surface Water Use... 3-55
3.2.4 Mitigations..... 3-55
3.3 CLIMATE..... 3-60
3.4 AIR QUALITY..... 3-61
3.4.1 Impacts..... 3-61
3.4.2 Mitigations..... 3-65
3.5 NOISE..... 3-66
3.5.1 Impacts..... 3-66
3.5.2 Mitigations..... 3-66
3.6 SOILS..... 3-68
3.6.1 Soil Handling Procedures..... 3-68
3.6.2 Area A..... 3-71
3.6.3 Area B..... 3-73

TABLE OF CONTENTS
(Continued)

		Page
3.6.4	Area C	3-73
3.6.5	Area D	3-76
3.6.6	Area E	3-77
3.6.7	Mitigations	3-77
3.7	VEGETATION	3-82
3.7.1	Area A	3-83
3.7.2	Area B	3-83
3.7.3	Area C	3-83
3.7.4	Area D	3-87
3.7.5	Area E	3-89
3.7.6	Conveyor Corridor	3-89
3.7.7	Mitigations	3-89
3.8	WILDLIFE	3-91
3.8.1	Big Game	3-92
3.8.2	Other Mammals	3-92
3.8.3	Mammalian Predators	3-92
3.8.4	Upland Game Birds	3-93
3.8.5	Waterfowl	3-93
3.8.6	Songbirds	3-93
3.8.7	Raptors	3-93
3.8.8	Reptiles and Amphibians	3-94
3.8.9	Fish	3-94
3.8.10	Threatened and Endangered Species	3-95
3.8.11	Mitigations	3-95
3.9	SOCIOLOGY AND ECONOMICS	3-96
3.9.1	Economic/Demographic Impacts	3-96
3.9.1.1	Economic Conditions	3-96
3.9.1.1.1	Employment and Population	3-96
3.9.1.1.2	Personal Income	3-99
3.9.1.1.3	Northern Cheyenne Reservation	3-99
3.9.2	Social Life Impacts	3-100
3.9.3	Social and Community Services Impacts	3-102
3.9.3.1	Law Enforcement	3-102
3.9.3.2	Fire Protection	3-103
3.9.3.3	Sanitary Sewer	3-103
3.9.3.4	Water Supply	3-103
3.9.3.5	Solid Waste	3-104
3.9.3.6	Social Welfare	3-104
3.9.3.7	Medical Services	3-104
3.9.3.8	General Government	3-105
3.9.3.9	Library	3-105
3.9.3.10	Housing	3-106
3.9.3.11	Education	3-106
3.9.3.12	Northern Cheyenne Reservation	3-107
3.9.4	Public Finance Impacts	3-108
3.9.5	Slowdown and Cessation of Coal Mining	3-110
3.9.5.1	Employment and Income	3-111
3.9.5.2	Social Conditions	3-111
3.9.6	Mitigations	3-113

TABLE OF CONTENTS
(Continued)

Page

3.10 LAND USE..... 3-115
3.10.1 Local Direct Impacts..... 3-115
3.10.2 Direct Regional Impacts..... 3-118
3.10.3 Indirect Impacts..... 3-118
3.10.4 Impacts along Conveyor Corridor..... 3-118
3.10.5 Mitigations..... 3-118
3.11 TRANSPORTATION..... 3-119
3.11.1 Road Systems..... 3-119
3.11.2 Railroad Systems..... 3-119
3.11.3 Other Systems..... 3-120
3.11.4 Northern Cheyenne Reservation..... 3-120
3.11.5 Mitigations..... 3-120
3.12 RECREATION..... 3-121
3.12.1 Urban Recreation Resources..... 3-121
3.12.2 Nonurban Recreation Resources..... 3-121
3.12.3 Mitigations..... 3-121
3.13 CULTURAL RESOURCES..... 3-122
3.13.1 Mining Areas A-E..... 3-122
3.13.2 Buffer Zone..... 3-122
3.13.3 Mitigations..... 3-134
3.14 ESTHETICS..... 3-135

SECTION 4.0 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY OF THE LANDS AFFECTED BY MINING..... 4-1

SECTION 5.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES.. 5-1

SECTION 6.0 CONSULTATION AND COORDINATION..... 6-1
6.1 DEVELOPMENT OF THE FINAL ENVIRONMENT IMPACT STUDY..... 6-1
6.2 AUTHORS..... 6-1

SECTION 7.0 REVIEW OF THIS STUDY..... 7-1

SECTION 8.0 RESPONSES TO HEARING TESTIMONY AND WRITTEN COMMENTS..... 8-1

SECTION 9.0 REFERENCES..... 9-1

LIST OF FIGURES

		Page
FIGURE 1.0-1	LOCATION OF ROSEBUD MINE	1-2
FIGURE 1.0-2	LOCATION OF AREAS A-E, ROSEBUD MINE	1-3
FIGURE 1.2-1	SEQUENCE OF MINING, ROSEBUD MINE	1-4
FIGURE 1.2-2	DURATION OF MINING IN EACH AREA OF THE ROSEBUD MINE	1-5
FIGURE 1.2-3	SURFACE OWNERSHIP AT THE ROSEBUD MINE	1-6
FIGURE 1.2-4	COAL LEASES AT THE ROSEBUD MINE	1-7
FIGURE 2.1-1	GENERAL COLUMNAR SECTION OF UPPER CRETACEOUS AND CENOZOIC ROCKS IN THE COLSTRIP AREA, NORTHWESTERN POWDER RIVER BASIN, MONTANA	2-2
FIGURE 2.1-2	OVERBURDEN GEOCHEMISTRY HOLE LOCATIONS, ROSEBUD MINE	2-6
FIGURE 2.2-1	HYDROLOGIC STUDY AREA SHOWING DRAINAGES WITH APPROXIMATE COAL SEAM OUTCROPS/SUBCROPS	2-11
FIGURE 2.2-2	SCHEMATIC CROSS SECTION OF GROUNDWATER MOVEMENT THROUGH SPOILS AND SURROUNDING MATERIAL, ROSEBUD MINE AREA, MONTANA	2-12
FIGURE 2.2-3	REFERENCE MAP OF WELLS, SPRINGS AND SURFACE WATER STATIONS	2-16
FIGURE 2.2-4	POTENTIOMETRIC SURFACE OF SPOILS AQUIFER, ROSEBUD MINE, MONTANA	2-20
FIGURE 2.2-5	POTENTIOMETRIC SURFACE MAP OF VALLEY FILL AQUIFER, ROSEBUD MINE, MONTANA	2-21
FIGURE 2.2-6	REGIONAL POTENTIOMETRIC SURFACE OF ROSEBUD COAL AQUIFER, ROSEBUD & BIG SKY MINES, MONTANA	2-23
FIGURE 2.2-7	POTENTIOMETRIC SURFACE AND STRUCTURAL CROSS SECTION ACROSS TWO FAULTS, ROSEBUD MINE, MONTANA	2-24
FIGURE 2.2-8	REGIONAL POTENTIOMETRIC SURFACE OF MCKAY COAL AQUIFER, ROSEBUD & BIG SKY MINES, MONTANA	2-25
FIGURE 2.2-9	RECHARGE/DISCHARGE AREAS OF THE VALLEY FILL MATERIAL FOR EAST FORK ARMELLS CREEK, ROSEBUD MINE AREA, COLSTRIP, MONTANA	2-28
FIGURE 2.2-10	SCHEMATIC WEST-EAST CROSS SECTION ACROSS SURGE POND, COLSTRIP, MONTANA	2-29
FIGURE 2.2-11	ROSEBUD COAL AND MCKAY COAL RECHARGE/DISCHARGE AREAS, ROSEBUD MINE, MONTANA	2-32
FIGURE 2.2-12	POTENTIAL SUBIRRIGATED AREAS, ROSEBUD MINE, MONTANA	2-34
FIGURE 2.2-13	WATER QUALITY MAP SHOWING AREAS AFFECTED AND POTENTIALLY AFFECTED BY HUMAN ACTIVITIES, ROSEBUD MINE AREA	2-35
FIGURE 2.2-14	COMPUTER SIMULATED TOPOGRAPHIC SURFACE, ROSEBUD MINE AREA	2-42
FIGURE 2.2-15	PROBABILITY OF FLOW OCCURRENCE	2-48
FIGURE 2.2-16	RELATIONSHIPS BETWEEN SELECTED CHEMICAL CONSTITUTENTS FOR EAST FORK ARMELLS CREEK AT USGS STATION NEAR COLSTRIP, MONTANA	2-51
FIGURE 2.2-17	RELATIONSHIPS BETWEEN SELECTED CHEMICAL CONSTITUTENTS FOR ROSEBUD CREEK AT USGS STATION NEAR COLSTRIP, MONTANA	2-52
FIGURE 2.3-1	COLSTRIP AREA ANNUAL WIND FREQUENCY DISTRIBUTIONS	2-61
FIGURE 2.4-1	HIGH VOL. & MET. STATIONS	2-65

LIST OF FIGURES
(Continued)

		Page
FIGURE 2.6-1	GENERAL SOILS MAP, ROSEBUD MINE	2-71
FIGURE 2.7-1	GENERAL VEGETATION MAP, ROSEBUD MINE	2-82
FIGURE 2.8-1	CUMULATIVE PRONGHORN ANTELOPE AERIAL SURVEY OBSERVATIONS, 1978-1980	2-88
FIGURE 2.8-2	CUMULATIVE MULE DEER AERIAL SURVEY OBSERVATIONS, 1978-1980	2-90
FIGURE 2.8-3	APPROXIMATE LOCATIONS OF SHARP-TAILED GROUSE DANCING GROUNDS	2-94
FIGURE 2.11-1	TRANSPORTATION ROUTES NEAR COLSTRIP	2-136
FIGURE 2.13-1	MAP OF PROJECT AREA SHOWING LANDS SURVEYED FOR CULTURAL RESOURCES	2-145
FIGURE 3.2-1	PREDICTED DRAWDOWN, ROSEBUD COAL AQUIFER, YEAR 1988, ROSEBUD MINE AREA, MONTANA	3-12
FIGURE 3.2-2	PREDICTED DRAWDOWN, ROSEBUD COAL AQUIFER, YEAR 2018, ROSEBUD MINE AREA, MONTANA	3-13
FIGURE 3.2-3	PREDICTED DRAWDOWN, ROSEBUD COAL AQUIFER, YEAR 2118, ROSEBUD MINE AREA, MONTANA	3-14
FIGURE 3.2-4	TIME-DRAWDOWN PLOT, AREA A	3-24
FIGURE 3.2-5	TIME-DRAWDOWN PLOT, AREA B	3-25
FIGURE 3.2-6	TIME-DRAWDOWN PLOT, AREA C AND BLOCK I	3-26
FIGURE 3.2-7	TIME-DRAWDOWN PLOT, AREA D	3-27
FIGURE 3.2-8	TIME-DRAWDOWN PLOT, AREA E	3-28
FIGURE 3.2-9	TIME-DRAWDOWN PLOT, BIG SKY MINE	3-29
FIGURE 3.2-10	COMPUTER-GENERATED POST-MINE EROSIONAL RATES, ROSEBUD MINE	3-37
FIGURE 3.2-11	COMPUTER-GENERATED POST-MINE EROSIONAL RATES, ROSEBUD MINE, WHERE POST-MINE EROSION EXCEEDS PRE-MINE EROSION	3-38
FIGURE 3.2-13	REFERENCE MAP OF ROSEBUD MINE SPOILS, INDUSTRIAL AND MUNICIPAL WASTEWATER PONDS, AND ASSOCIATED MONITORING WELLS	3-44
FIGURE 3.4-1	ISOPLETHS OF ANNUAL AVERAGE TSP CONCENTRATION IN $\mu g/m^3$, RESULTING FROM 1980 SOURCES OF PARTICULATE MATTER IN COLSTRIP	3-57
FIGURE 3.4-2	ISOPLETHS OF ANNUAL-AVERAGE TSP CONCENTRATION IN $\mu g/m^3$, RESULTING FROM 1988 SOURCES OF PARTICULATE MATTER IN COLSTRIP	3-58
FIGURE 3.4-3	ISOPLETHS OF INCREASES IN ANNUAL-AVERAGE TSP CONCENTRATION IN $\mu g/m^3$, FROM 1980-1988	3-59

LIST OF TABLES

		Page
TABLE 1.2-1	PRODUCTION BY AREA	1-8
TABLE 2.1-1	CHARACTERISTICS OF LANDSCAPE UNITS IN THE COLSTRIP AREA	2-3
TABLE 2.1-2	PERCENTAGE OF SAMPLES EXCEEDING STATE SUSPECT LEVELS IN OVERBURDEN TEST HOLES, ROSEBUD MINE, MONTANA	2-7
TABLE 2.1-3	PROJECTED PRODUCTION AT THE ROSEBUD MINE, 1980-2017	2-9
TABLE 2.2-1	SUMMARY OF TRANSMISSIVITY AND HYDRAULIC CONDUCTIVITY VALUES FOR AQUIFER TESTS IN THE ROSEBUD MINE AREA	2-14
TABLE 2.2-2	ESTIMATED POND SEEPAGE AMOUNTS	2-31
TABLE 2.2-3	FLOOD MAGNITUDE CALCULATIONS FOR STOCKER CREEK AT MOUTH	2-45
TABLE 2.2-4	FLOOD MAGNITUDE CALCULATIONS FOR EAST FORK ARMELLS CREEK AT CONFLUENCE WITH STOCKER CREEK	2-45
TABLE 2.2-5	FLOOD MAGNITUDE CALCULATIONS FOR PONY CREEK	2-46
TABLE 2.2-6	FLOOD MAGNITUDE CALCULATIONS FOR COW CREEK (Excluding Area E Disturbed Area)	2-46
TABLE 2.2-7	FLOW STATISTICS FOR SELECTED STREAMS, ROSEBUD MINE AREA	2-47
TABLE 2.4-1	MONTANA AND NATIONAL AIR QUALITY STANDARDS	2-64
TABLE 2.5-1	SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY	2-69
TABLE 2.6-1	SOIL DISTRIBUTION, AREA A	2-73
TABLE 2.6-2	SOIL DISTRIBUTION, AREA B	2-75
TABLE 2.6-3	SOIL DISTRIBUTION, AREA C	2-76
TABLE 2.6-4	SOIL DISTRIBUTION, AREA D	2-78
TABLE 2.6-5	SOIL DISTRIBUTION, AREA E	2-80
TABLE 2.7-1	VEGETATION, AREAS A THROUGH E	2-81
TABLE 2.8-1	SMALL MAMMALS TRAPPED IN COLSTRIP VICINITY DURING THE PERIOD 1973 THROUGH 1978	2-91
TABLE 2.8-2	MAXIMUM NUMBER OF MALE SHARP-TAILED GROUSE ATTENDING DANCING GROUNDS ON THE WESTERN ENERGY COMPANY STUDY AREA DURING THE SPRINGS OF 1973 THROUGH 1981	2-95
TABLE 2.8-3	SONGBIRD BREEDING DENSITIES FOR FOUR HABITAT TYPES ON THE WESTERN ENERGY COMPANY STUDY AREA, 1981	2-97
TABLE 2.10-1	SUMMARY OF LAND USE IMPACTS OF THE ROSEBUD MINE	2-131
TABLE 2.10-2	CURRENT LAND USE IN THE ROSEBUD MINE AREA	2-132
TABLE 2.11-1	AVERAGE DAILY TRAFFIC COUNTS FOR HIGHWAYS NEAR COLSTRIP, 1968-1981	2-137
TABLE 2.12-1	NONURBAN DEVELOPED RECREATION SITE INVENTORY - ROSEBUD COUNTY	2-140
TABLE 2.13-1	REPORTS AND/OR FIELDWORK PERTAINING TO ROSEBUD MINE DIRECT IMPACT AREA AND BUFFER ZONE	2-143
TABLE 2.13-2	SITES IN PROJECT AREA: DIRECT IMPACT AREA A	2-147
TABLE 2.13-3	SITES IN PROJECT AREA: DIRECT IMPACT AREA B	2-148

LIST OF TABLES
(Continued)

Page

TABLE 2.13-4 SITES IN PROJECT AREA: DIRECT IMPACT AREA C 2-149
TABLE 2.13-5 SITES IN PROJECT AREA: DIRECT IMPACT AREA D 2-153
TABLE 2.13-6 SITES IN PROJECT AREA: DIRECT IMPACT AREA E 2-156
TABLE 2.13-7 SITES IN BUFFER ZONE (INDIRECT IMPACT AREA)..... 2-157
TABLE 2.13-8 SITES IN THE PROJECT AREA WITH POTENTIAL RELIGIOUS SIGNIFICANCE..... 2-161

TABLE 3.1-1 GENERALIZED CHARACTERISTICS OF RECLAIMED LANDSCAPE..... 3-2
TABLE 3.2-1 ANTICIPATED HYDROLOGIC IMPACTS IN THE COLSTRIP AREA ASSOCIATED WITH COAL MINING AND MINING-RELATED ACTIVITIES..... 3-8
TABLE 3.2-2 DRAWDOWN EFFECTS OF MINING ROSEBUD OVERBURDEN AND ROSEBUD COAL SEAM, (in vertical feet), ROSEBUD MINE AREA, MONTANA..... 3-11
TABLE 3.2-3 MODELED GROUNDWATER DISCHARGE,* MINING IMPACTS TO SURFACE DRAINAGES (acre-feet per year)..... 3-16
TABLE 3.2-4 COW CREEK VALLEY FILL MATERIAL WATER QUALITY..... 3-19
TABLE 3.2-5 WELLS AND SPRINGS AFFECTED BY MINING (LIFE OF MINE), ROSEBUD AND BIG SKY MINES, ROSEBUD COUNTY, MONTANA..... 3-21
TABLE 3.2-6 PRE- AND POST- MINE PEAK FLOWS (in cubic feet per second)..... 3-40
TABLE 3.2-7 PRE- AND POST- MINE SURFACE FLOW VOLUMES (in acre fee)... 3-40
TABLE 3.4-1 PARTICULATE MATTER EMISSIONS RATES..... 3-62
TABLE 3.5-1 MEASURED SOUND LEVELS DUE TO BLASTING..... 3-67
TABLE 3.6-1 TOPSOIL AND SUBSOIL SELECTION CRITERIA..... 3-69
TABLE 3.6-2 CHARACTERISTICS OF GENERAL SOIL GROUPS, ROSEBUD MINE..... 3-70
TABLE 3.6-3 SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA A..... 3-72
TABLE 3.6-4 SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA B..... 3-74
TABLE 3.6-5 SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA C..... 3-75
TABLE 3.6-6 SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA D..... 3-78
TABLE 3.6-7 SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA E..... 3-79
TABLE 3.7-1 EXISTING AND EXPECTED POST-MINED VEGETATION, AREA A..... 3-84
TABLE 3.7-2 EXISTING AND EXPECTED POST-MINED VEGETATION, AREA B..... 3-85
TABLE 3.7-3 EXISTING AND EXPECTED POST-MINED VEGETATION, AREA C..... 3-86
TABLE 3.7-4 EXISTING AND EXPECTED POST-MINED VEGETATION, AREA D..... 3-88
TABLE 3.7-5 EXISTING AND EXPECTED POST-MINED VEGETATION, AREA E..... 3-90
TABLE 3.10-1 SUMMARY OF LAND USE CHANGES..... 3-116
TABLE 3.13-1 TOTAL CULTURAL RESOURCE IMPACTS BY AREA..... 3-123
TABLE 3.13-2 SUMMARY OF IMPACT TO CULTURAL RESOURCES: MINING AREA A.. 3-124
TABLE 3.13-3 SUMMARY OF IMPACT TO CULTURAL RESOURCES: MINING AREA B.. 3-125
TABLE 3.13-4 SUMMARY OF IMPACT TO CULTURAL RESOURCES: MINING AREA C.. 3-126
TABLE 3.13-5 SUMMARY OF IMPACT TO CULTURAL RESOURCES: MINING AREA D.. 3-129
TABLE 3.13-6 SUMMARY OF IMPACT TO CULTURAL RESOURCES: MINING AREA E.. 3-132
TABLE 3.13-7 CULTURAL RESOURCES THAT MAY BE INDIRECTLY IMPACTED BY BLASTING: BUFFER ZONE AREA..... 3-133

0.0 INTRODUCTION

Western Energy Company has proposed in the Comprehensive Mine Plan to expand the Rosebud Mine and then operate the mine through 2017. Western Energy's plan is analyzed in this environmental impact study.

The reader should note that the comprehensive plan is a general outline of the company's future operations. To carry out the plan, the company must, as the mine is developed, prepare detailed mine plans. These detailed plans must then be approved by the Department of State Lands (DSL) and the U.S. Office of Surface Mining (OSM).

0.1 THE COMPREHENSIVE STUDY: WHY IT IS WRITTEN, WHAT IT EXPLAINS

This study is not the first to be written on the Rosebud Mine. Eight environmental impact statements (EIS's) have been published since 1973, each dealing with a different part of the operation or regional coal development. EISs are required when an operation may "significantly affect the quality of the human environment" (Montana Environmental Policy Act [MEPA], 1971, and National Environmental Policy Act [NEPA], 1969).

This study, unlike the EIS's, is the first to look at the entire mine in one analysis. Further, this study does not describe a mine plan for which Western Energy seeks approval. Instead, the study describes a plan submitted for analysis only. For now, the analysis is meant merely to describe and inform. Later, as Western Energy submits specific plans for mining--detailed maps and explanatory text--new "site-specific" environmental analyses will be prepared. For these, the comprehensive study will be a parent document.

The Comprehensive Study will serve as a parent in two ways. First, it will provide a source of information, serving as a basis for site-specific EIS's and environmental analyses to be written in the future. Second, it will discuss "cumulative" impacts--that is, the impacts expected to arise during the entire mine life in all parts of the mine added together.

0.2 THE EIS PROCESS

Although different from EIS's, the Comprehensive Study has followed the EIS process required by NEPA and MEPA. To date, DSL and OSM have issued a draft study (in March 1983) and encouraged and accepted public comments on the draft (until May 9, 1983).

With the publication of this final study, the Department and OSM have completed the EIS process. This final document contains corrections or clarifications of the draft study and responses to each substantive comment.

0.3 THE CONTENTS OF THE STUDY

The Comprehensive Study contains the same information contained in most EISs. The document starts with a description of the company's proposal--in this case a general description of Western Energy's plan for the life of the mine (chapter 1). Then there is a description of the lands, people, and other resources that would be affected by the mine (chapter 2). Next is a description of the impacts--all unavoidable--expected to occur if the mine plan is implemented (chapter 3). These three chapters make up the bulk of the document.

Additional sections important to the document include the descriptions of (1) irreversible and irretrievable commitments of resources and (2) short-term uses versus long-term productivity of the lands proposed for mining. These two considerations are included in the discussion of the impacts in chapter 3. For the reader's convenience, they are repeated separately (chapters 4 and 5).

1.0 DESCRIPTION OF THE PROPOSAL UNDER CONSIDERATION

Rosebud Mine is located in Rosebud County, Montana. The mine surrounds the town of Colstrip, extending about 8 miles southwest, 5 miles southeast, and 4 miles northeast of the townsite. (See fig. 1.0-1) Western Energy has divided the mine into five parts: Areas A, B, C, D, and E. (See fig. 1.0-2) Sections of Area A have been mined. Parts of B and E are now being mined. Areas C and D have not yet been developed although Block I of Area C is under construction. To some extent, each mine area operates independently from the others.

1.1 MINE HISTORY

The Northern Pacific Railroad initiated coal mining in Colstrip. From 1924 to 1958, Northern Pacific mined about 44 million tons of coal from the Rosebud seam to fuel steam-powered locomotives. By 1958, the company had disturbed 1,800 acres of land around what is now Area E. (See fig. 1.0-2).

When the Northern Pacific replaced steam-powered engines with diesel locomotives, the company stopped mining. In 1959, Montana Power Company bought the townsite of Colstrip and the mining leases owned by the Northern Pacific. Montana Power then, in 1966, formed a wholly owned subsidiary, Western Energy Company, to manage and develop the Colstrip properties.

Western Energy began mining in 1968 in the area, known as Pit 6, where Northern Pacific left off. The company finished mining Pit 6 and has since expanded the mine far beyond its initial size.

1.2 THE ROSEBUD MINE TODAY

1.2.1 Mine Schedule

Western Energy's current plan for the Rosebud Mine covers about 22,000 acres. Of this total, about 9,000 have already been permitted by the Department of State Lands and the U.S. Office of Surface Mining--in Areas A, B, C, and E. Of the 9,000 permitted acres, about 5,400 have already been disturbed--Areas A, B, and E.

The mine is scheduled to operate until 2017 and will be developed in the sequence shown in figures 1.2-1 and 1.2-2.

1.2.2 Coal Reserves and Production

A number of coal seams lie within the Rosebud Mine. Two of these, the Rosebud and the McKay, are mineable by today's surface mining technology. Western Energy, however, would mine only the Rosebud seam, the upper of the two. The McKay seam, lying an average of 23 feet below the Rosebud, is of poorer quality, containing higher amounts of sulfur, iron, and sodium than the Rosebud. The iron makes the McKay coal tend to slag at normal boiler operating temperatures; the sodium increases the likelihood of boiler tube

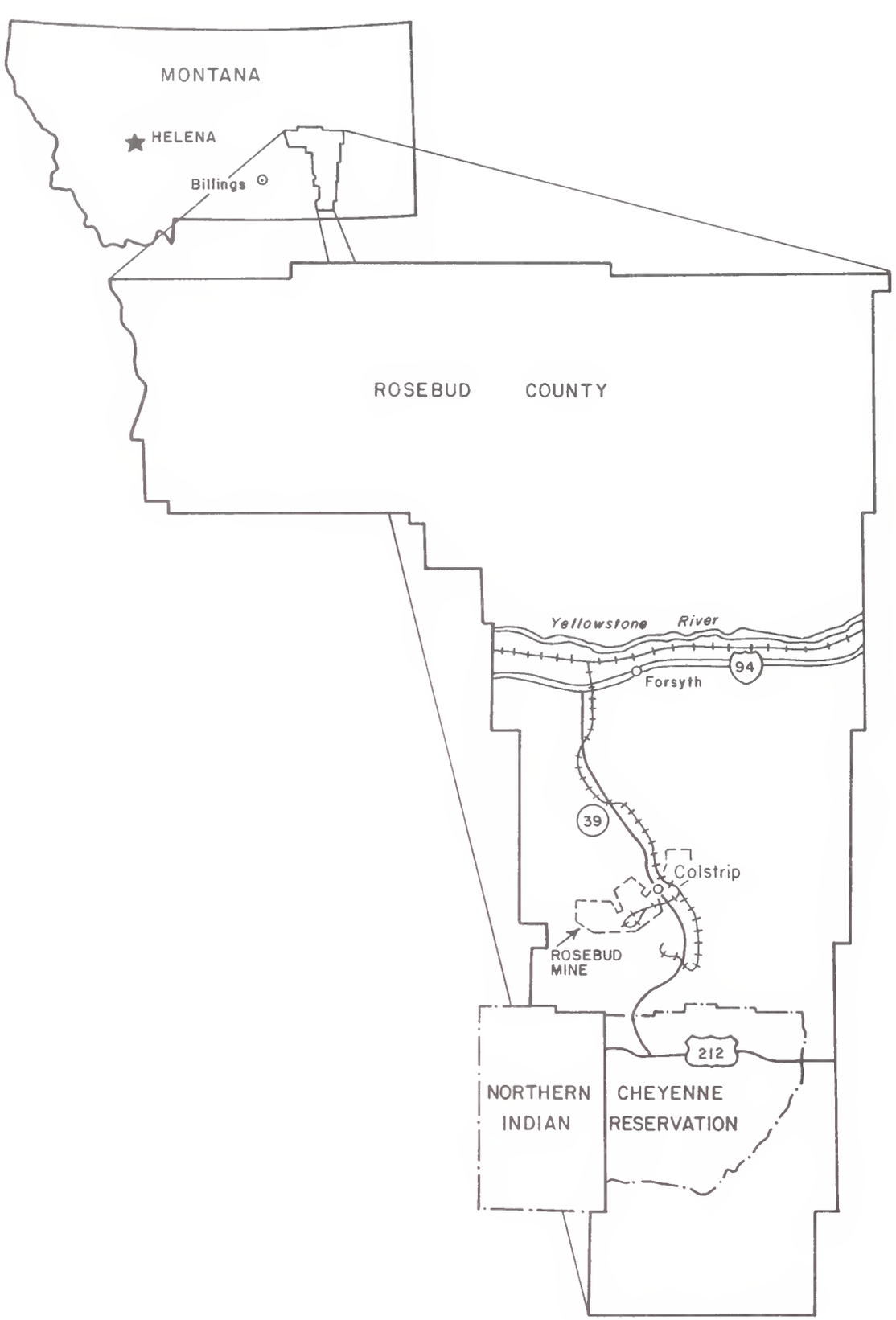
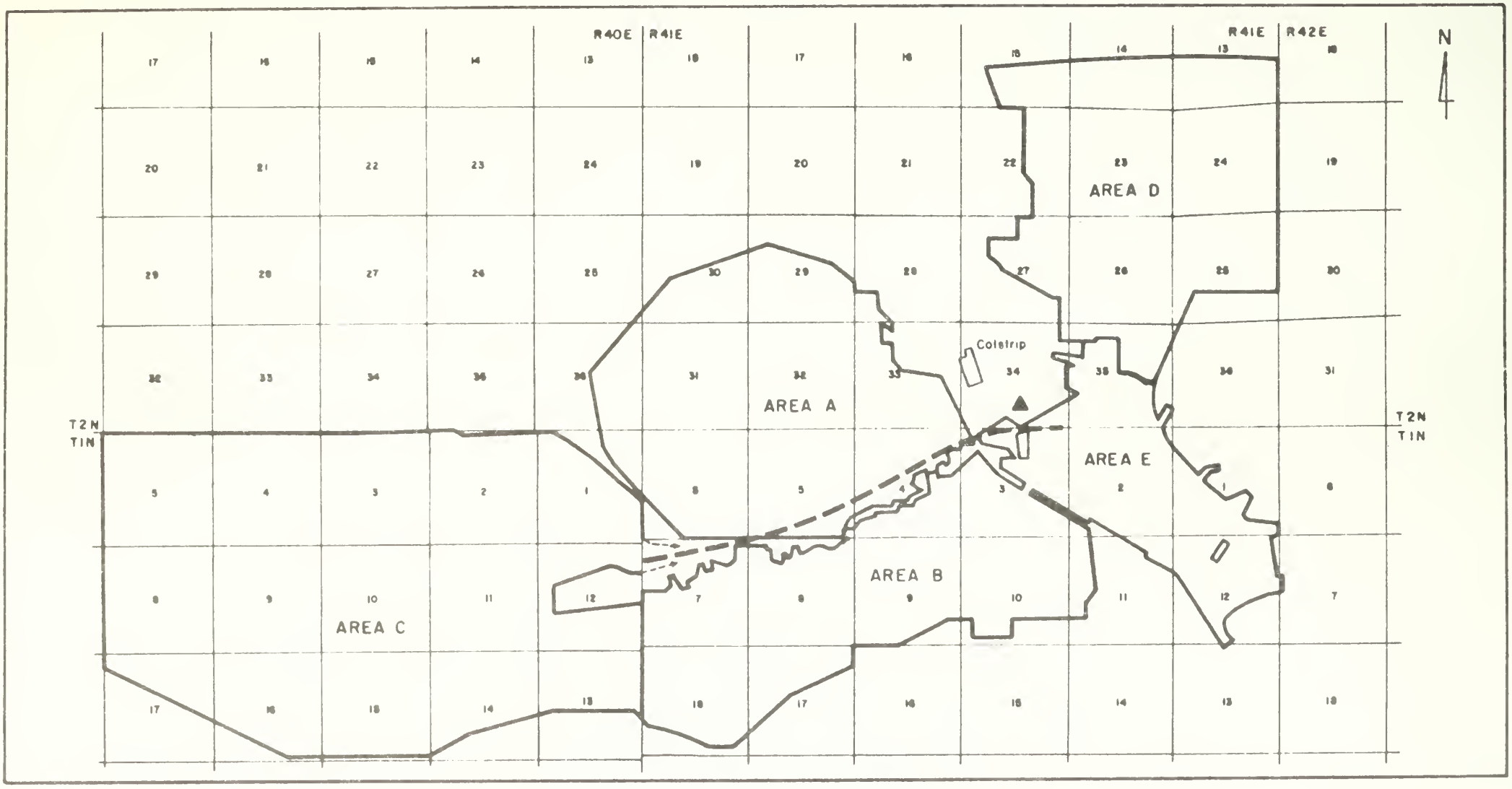


FIGURE 1.0-1 LOCATION OF ROSEBUD MINE



LEGEND

CONVEYOR ROUTE

▲ LOCATION OF MPC GENERATING UNITS

SCALE: 1" = 7540'

FIGURE 1.0-2 LOCATION OF AREAS A-E, ROSEBUD MINE

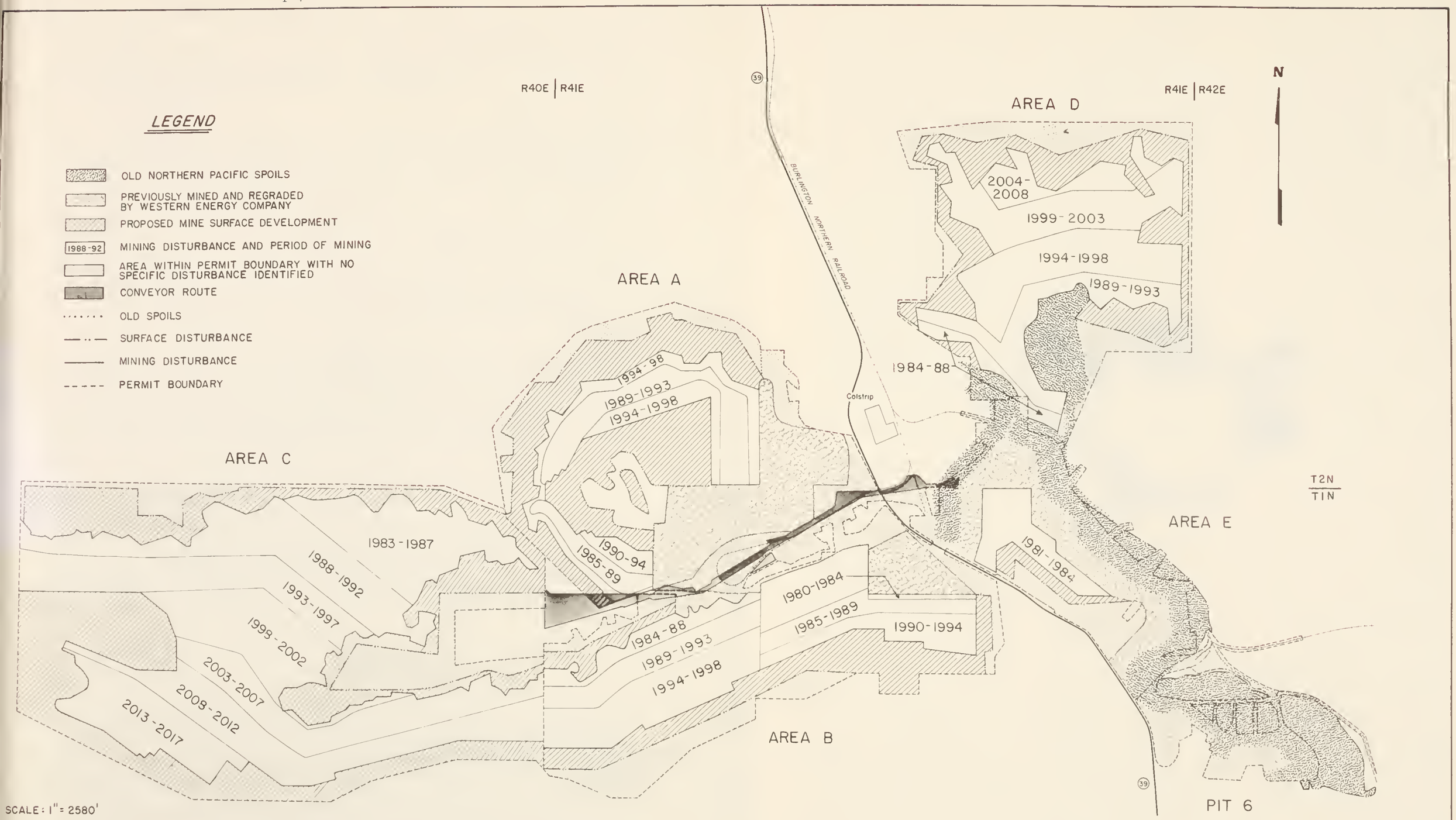


FIGURE 1.2-1 SEQUENCE OF MINING, ROSEBUD MINE

SOURCE: WESTERN ENERGY COMPREHENSIVE MINE PLAN, JULY 1981

deterioration. Western Energy has not found a market for the McKay coal and does not plan to mine the seam, although the nearby Peabody Mine does mine and market a blend of the McKay and Rosebud coal.

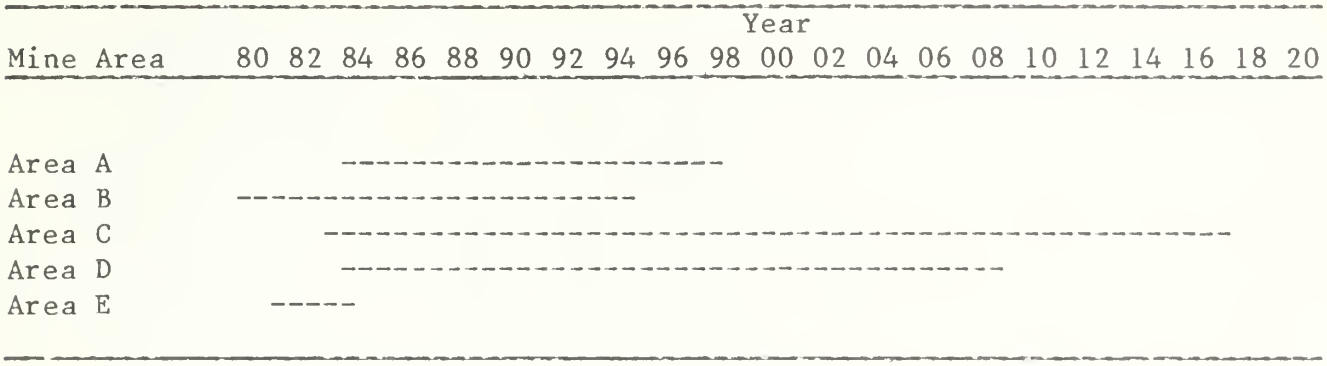


Figure 1.2-2--Duration of Mining in Each Area of the Rosebud Mine

About 377 million tons of recoverable coal lie in the areas proposed for mining. The coal is leased by Western Energy from Burlington Northern and the Federal Government. Surface ownership and coal leases for the mine are shown in figures 1.2-3 and 1.2-4. Western Energy conveys some of the coal to Montana Power Company's power-generating facilities and ships the remainder by train to other power plants in the West and Midwest. Table 1.2-1 lists projected coal production, by area, from 1980 to 2017.

1.2.3 Employment at the Mine

Rosebud Mine employment now totals about 325 people. The addition of personnel for Area C, which will soon start, will increase the total to about 500. Employment is projected to peak in 2003 at about 525 people and remain constant for the remainder of the mine's life. For 2 years during the construction of Area C, Western Energy will require an additional 300 to 400 construction employees.

1.3 MINING PLAN

1.3.1 Facilities

The Rosebud Mine now has two sets of mine facilities: one at Area E and one shared by Areas A and B. The Area A and B facilities include the following: a hopper, primary crusher, secondary crusher, stacker, crushed-coal stockpile, reclaim tunnel, and train loadout. The Area E facilities include a hopper, primary crusher, secondary crusher, train loadout, and transfer conveyor.

For Area C, Western Energy plans to build a third set of facilities. The company will divide the facilities into two parts: (1) a shop and office facility and (2) a coal crusher and conveyor facility. An overland

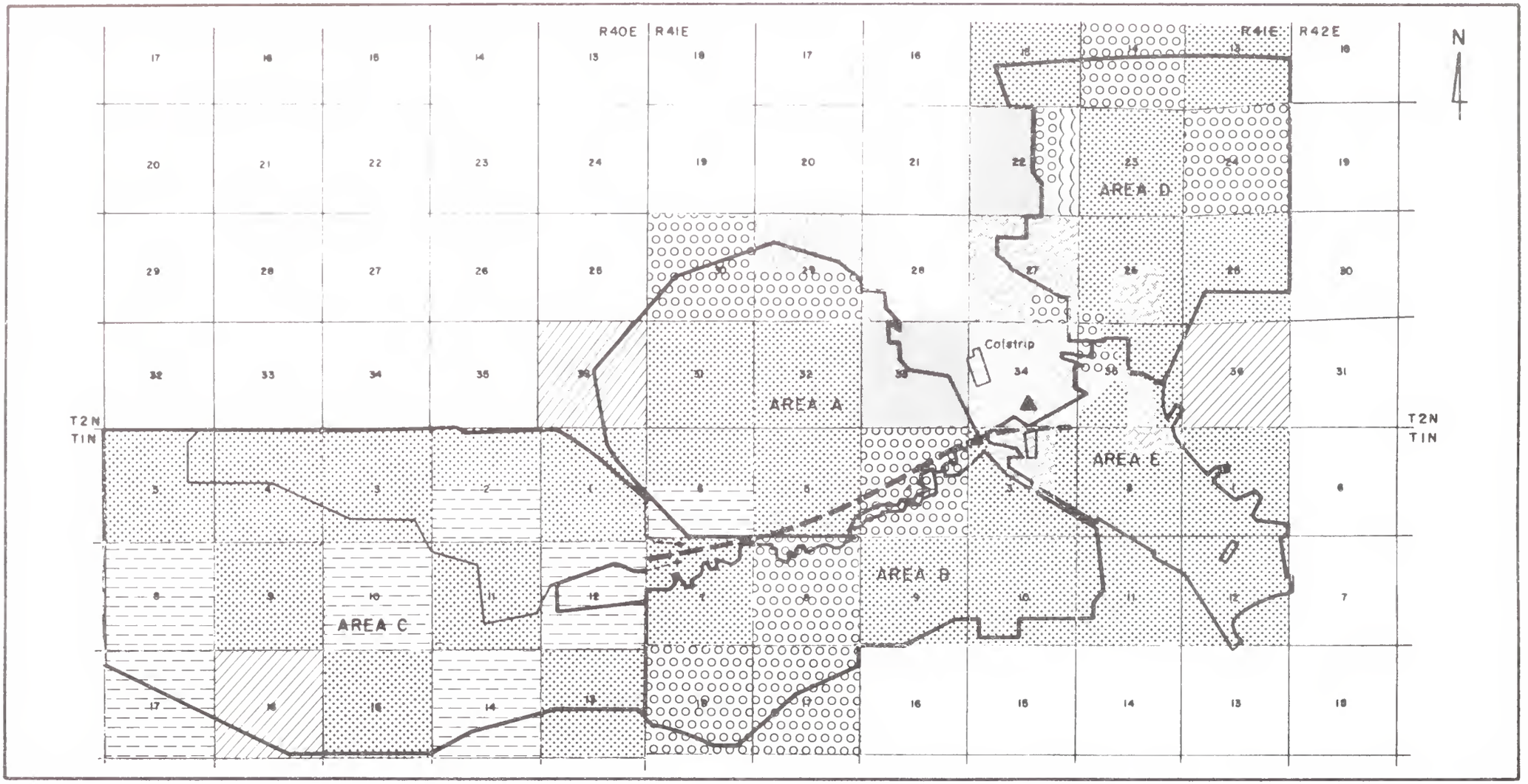
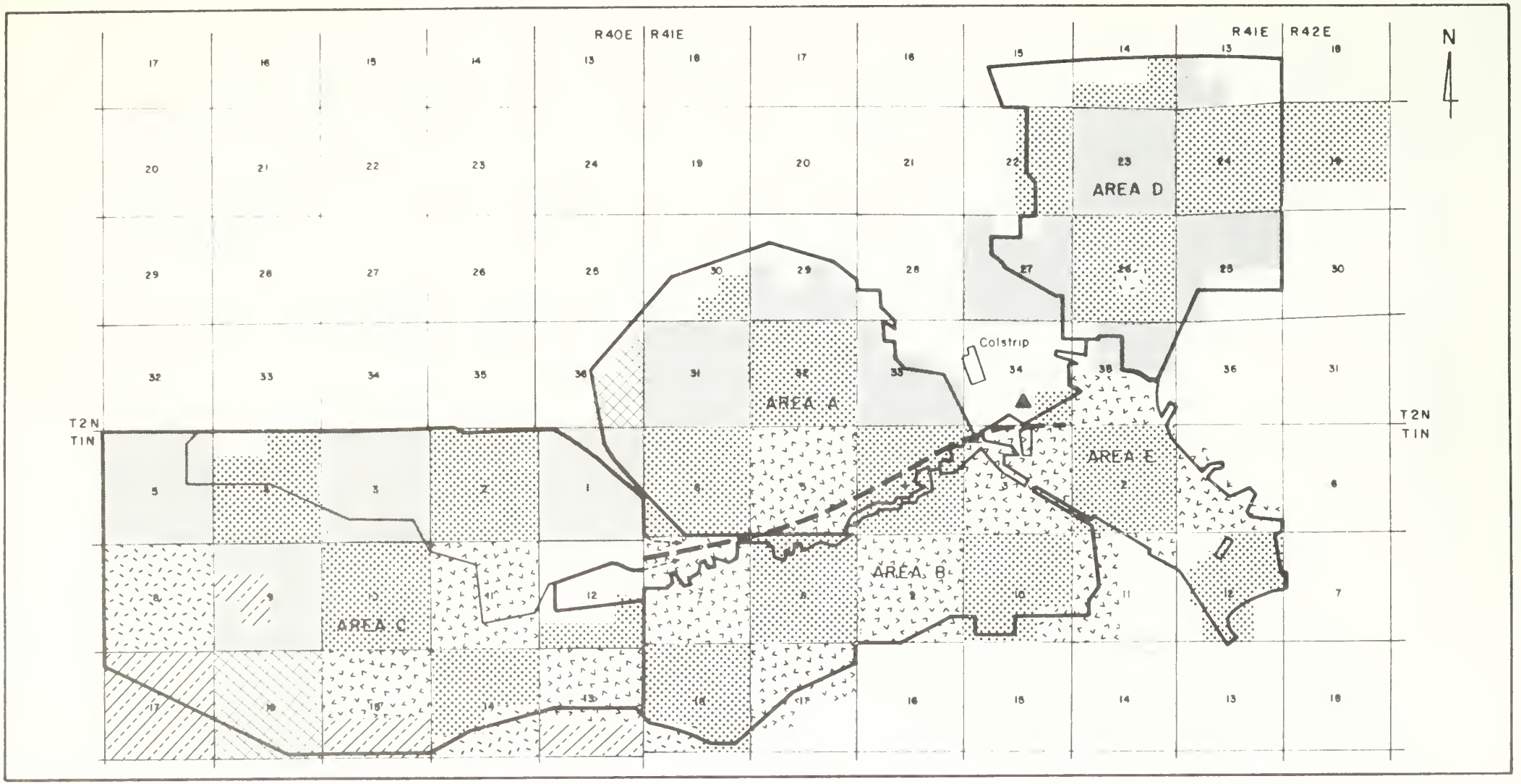


FIGURE 1.2-3 SURFACE OWNERSHIP AT THE ROSEBUD MINE



LEGEND

- CONVEYOR ROUTE
- LOCATION OF MPC GENERATING UNITS
- SCALE: 1"=7540'
- BN T&M CONTRACT 4578
- BN T&M CONTRACT 3982
- FEDERAL LEASES
- FEDERAL UNLEASED
- STATE OF MONTANA
- BN UNLEASED

FIGURE 1.2-4 COAL LEASES AT THE ROSEBUD MINE

TABLE 1.2-1

PRODUCTION BY AREA

PRODUCTION (million tons)

Area	1980-84	1985-89	1990-94	1995-99	2000-04
E	11.7	--	--	--	--
D	4.0	20.0	20.0	20.0	4.0
A	8.0	20.0	9.6	--	--
B (4,9,10)	18.0	10.0	15.2	--	--
B (7,8,17,18)	6.0	10.0	15.2	--	--
TOTAL	47.7	60.0	60.0	20.0	4.0

PRODUCTION (million tons)

Area	1983-87	1988-92	1993-97	1998-02	2003-07	2008-12	2012-17
C	25.0	30.0	30.0	25.0	25.0	25.0	25.0

conveyor, beginning at the crusher facility, will extend a distance of five miles to Montana Power Company's Colstrip Generating Units 3 and 4.

In addition to the coal-processing and support structures built for the mine, a network of roads will link each part of the mine together. The road system will comprise three types of roads: access, ramp, and haul roads. The ramp roads will be constructed into the pit. The access and haul roads will complete the network outside the pit. Conveyors will carry the coal from the crushers to the loadout, a facility that loads coal onto unit trains for shipment to customers.

1.3.2 Mining Method

In all of its Rosebud Mine operations, Western Energy now uses the area surface mining method, in which a dragline excavates the overburden (rock and dirt) lying over the coal. Mining in each new mine area begins when the dragline excavates a long, flat-bottomed trench called the boxcut (the first cut of the mine). Mining advances as the dragline digs another trench alongside the first, a third trench alongside the second, and so on. Over time, the dragline works across the entire mine area by cutting these parallel trenches (or pits). The company intends to mine the entire Rosebud Mine using this method.

The mining process actually begins before dragline excavations. Scrapers first strip the topsoil to an average depth of 6 to 8 inches. The scrapers then strip subsoil to an average depth (below topsoil) of 2.5 feet. Following soil removal, the overburden is drilled and blasted. Then the dragline follows and excavates overburden down to the Rosebud seam.

The Rosebud seam is drilled and blasted in the same way as the overburden. Electric shovels, front-end loaders, or backhoes then load the coal into coal haulers (dump trucks), which transport the coal to the coal hopper. At the hopper, the primary and secondary crushers break the coal to a top size of 3 inches, and this coal is then either shipped to customers or conveyed to the Colstrip generating plants.

During boxcut excavation, topsoil, subsoil, and overburden are dumped in segregated storage piles outside the area to be mined. During excavation of the second and later cuts, however, the dragline casts the overburden directly into the mined-out cut, or pit, left after coal extraction. Likewise, scrapers, taking topsoil and subsoil from later cuts, respread the soil on mined-out pit areas that have been filled with overburden and regraded. Direct backhaul of soil, as this is called, avoids stockpiling, which has a detrimental effect on the soil.

1.4 RECLAMATION PLAN

Once the dragline has cast spoil (unearthed overburden) from the active mining pit into the adjacent mined-out pit, bulldozers and scrapers grade the spoils to approximately the pre-mining contour. The scrapers and dozers grade only along the contour, to minimize erosion and provide a sur-

face that minimizes topsoil slippage. Slopes do not exceed 5:1 (20 percent). Any spoil material determined to be potentially harmful to the growth of plant life after mining is buried under 8 feet of nontoxic overburden.

During the final stages of spoil regrading, Western Energy reconstructs the approximate premining drainages. Drainages are graded with a continuous concave profile, thereby avoiding nick points (short gullies through bulges in the profile). At the lower end of reconstructed drainages, the company builds sedimentation ponds, to prevent untreated runoff from entering surface waters outside the mine area.

When Western Energy reaches the edge of the area to be mined, the mine creates a "highwall," that is, a steep cut rising from the base of the Rosebud seam to the undisturbed surface. The company fills the pit with stored boxcut spoils and then uses dozers and scrapers to break down, or "reduce," the remaining highwall and regrade it into slopes no steeper than 5:1. During the process, the mined area is graded into the undisturbed land to make a smooth and stable transition in topography.

Following the spoils grading, scrapers continue the reclamation process by spreading subsoil to a depth of 2 to 2.5 feet and topsoil to a depth of 6 to 8 inches. Soils with sandy textures, which erode easily, are distributed only on surfaces with less than a 10:1 (10 percent) slope, outside reconstructed drainages.

To prepare the seedbed, Western Energy first fertilizes the soil. Then the company chisel plows the soil to make a rough seedbed and incorporate the fertilizer. The surface is seeded in two steps with a permanent, diverse plant cover of predominantly native species. In the first step, Western Energy broadcast seeds a mixture of forbs, shrubs, and warm-season grasses. In the second step, 1 to 3 years after the first, the company seeds a cool-season perennial grass mixture. Seeding in two steps promotes diversity by avoiding the competition between cool season grasses (relatively strong competitors) and the plant varieties established in the first seeding step.

On slopes that are greater than 10:1, Western Energy applies mulch to the seeded surface. This controls erosion, promotes germination of seeds, and increases the moisture retention of the soil.

In addition to seeding, Western Energy transplants forbs, shrubs, and trees to the reclaimed lands. Where necessary, the company also plants nursery-grown shrubs and tube seedlings to reestablish shrub and woodland vegetation types.

Reclamation of the mined area would return the lands to rangeland for use by livestock and wildlife. Western Energy manages the land using primarily a deferred-rotation grazing system, implemented at the end of the land's third growing season.

2.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 GEOLOGY

The mine site is located on the gently dipping northwest flank of the Powder River Basin. Geologic formations that are exposed in the lease area are limited to the Tongue River Member of the Paleocence Fort Union Formation, and Quaternary Alluvium. Other formations are described in Figure 2.1-1.

2.1.1 Topography/Geomorphology

The Rosebud Mine lies within the unglaciated Missouri Plateau, a division of the Northern Great Plains physiographic province (Fenneman, 1931). The topography of this region, described by Keefer (1974) is characterized by open, high hills, with low to moderate relief.

The Rosebud Mine lies primarily within the East Fork Armells Creek drainage basin. Small parts of the mine lie within the headwaters of Stocker, Cow, Pony, and Spring Creeks. All of these are ephemeral to intermittent streams; they do not flow year round. Stocker Creek empties into East Fork Armells Creek north of the permit area, and East Fork Armells Creek runs generally north from there to the Yellowstone River. Cow, Spring and Pony Creeks are east-flowing tributaries to Rosebud Creek, which also runs north to the Yellowstone River. The drainage divides of East Fork Armells Creek and Stocker Creek are formed by either (1) prominent ridges of sandstone or resistant clinker caprock or (2) rounded hills on siltstone units. Small ephemeral drainages start from close to these upland crests and drain toward the main channels. Elevations within the proposed Rosebud Mine area range from 3,280 feet on lower East Fork Armells Creek to 3,680 feet in the upper Armells basin.

The landforms in the Rosebud Mine area have developed on the essentially flat-lying Tertiary sediments of the Fort Union Formation and can be divided into five major map units. The characteristics of these units are summarized in Table 2.1-1. Each landscape unit reflects modern processes acting on surficial materials with different geologic and geomorphic histories.

The most stable unit in the permit area is the Sandy Valley Bottom Unit (B_1). The low sediment yields from this unit are a consequence of the high infiltration rates, low drainage densities, and gentle gradients characteristic of this landscape component. The silty residual upland unit (U_2), is the most unstable unit. A moderate volume of runoff and sediment is derived from this unit. The relative instability of this landscape component is partly a consequence of its geologic history. Incision due to base level lowering has removed any protective surficial deposits, exposing the underlying bedrock. On these residual slopes blanketed by soils with low infiltration capacities, hillslope erosion processes dominate, resulting in increased sediment yields. A dense vegetation cover appears to play an important role in moderating erosion within this unit.

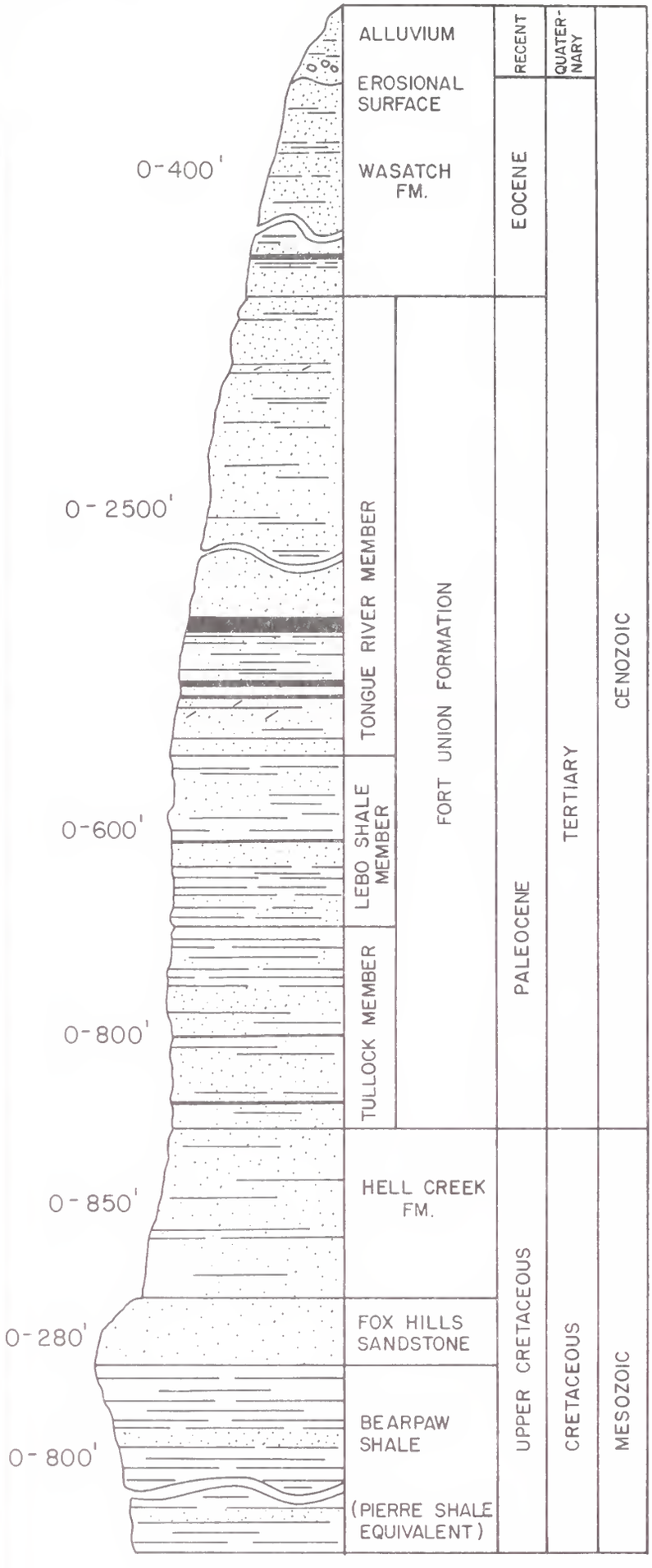


FIGURE 2.1-1

GENERAL COLUMNAR SECTION OF UPPER CRETACEOUS AND CENOZOIC ROCKS IN THE COLSTRIP AREA, NORTHWESTERN POWDER RIVER BASIN, MONTANA
(After Lewis and Roberts, 1978)

ALLUVIUM - Sand, silt, clay, and local gravel lenses and benches

WASATCH - Brownish-gray to light-gray, fine- to coarse-grained lenticular beds of sandstone and interbedded gray shale and coal. Base of unit is mapped as the top of the thick and persistent Roland coal bed, as defined by Baker (1929). Locally eroded off in the Rosebud Mine permit area.

TONGUE RIVER - Light-yellow to light-gray, fine- to medium-grained thick-bedded to massive locally crossbedded and lenticular sandstone and siltstone; weathers to a buff color. Commonly contains light-buff to light-gray shaly siltstone and shale, and brown to black carbonaceous shale. Contains numerous coal beds. Burning of the coal along outcrops has formed thick red and lavender clinker and baked shale beds. Base of unit is mapped as the change from predominantly siltstone and sandstone to predominantly shale of underlying unit.

LEBO SHALE - Predominantly dark shale containing interbeds of light-gray and brown to black carbonaceous shale, siltstone, and locally thin coal beds. Shales contain altered and devitrified volcanic ash and brown ferruginous concretions. Base of unit is mapped as the change from predominantly shale to predominantly fine-grained sandstone and shale of underlying unit. Conformable contact with underlying unit; however the Lebo exists locally as deposits in channels eroded deeply into the underlying Tullock member.

TULLOCK - Lower part of member is interbedded medium-gray to light-gray shale, fine-grained light-gray sandstone and siltstone, and thin but persistent coal beds; grades upward to light-gray carbonaceous shale. Locally at the top is a resis- sandstone that forms a well-developed rimrock. Base of unit is mapped as the change from fine-grain, thin-bedded sandstone, siltstone, shale, and coal beds to predominantly massive channel sandstone and dark-gray shale of underlying unit. (Brown, 1952 and Dunlap, 1958)

HELL CREEK - Shale and siltstone, gray to yellowish-gray, silty, clayey, sandy, carbonaceous, and bentonitic; locally, a yellowish-gray to tan, fine- to medium-grained silty sandstone containing thin coal beds predominates. Lower contact is gradational. Contact probably unconformable with underlying Fox Hills Sandstone or Bearpaw Shale.

FOX HILLS SANDSTONE - Near-shore sand facies that is the uppermost marine deposit in the area. Two members are recognized: Colgate Member -- very light-gray, fine- to medium-grained massive sandstone. Unnamed lower member -- gray to brownish-gray, fine-grained thin-bedded sandstone, interbedded with gray sandy shale and siltstone. Lower contact is gradational, considered to be the base of transition zone between sandstone above and shale of underlying unit. Conformable contact with underlying unit.

BEARPAW SHALE - Gray to black marine shaly claystone and shale. Contains some thin-bedded siltstone and silty sandstone, and locally thin beds of bentonite.

TABLE 2.1-1

CHARACTERISTICS OF LANDSCAPE UNITS IN THE COLSTRIP AREA

LANDSCAPE UNITS	TYPES OF SURFICIAL MATERIALS	RANGE OF SLOPE GRADIENT	VEGETATIVE COVER (%)	INFILTRATION RATE In/Hr.	ESTIMATED SEDIMENT YIELD (AF/Mi^2)
B_1 SANDY VALLEY BOTTOM	Sandy alluvial dept. & weathered residual sandstone	8%	60-70	2-6	0.15
B_2 SILTY VALLEY BOTTOM	Deep alluvium silts	<8%	50	0.2-0.6	x0.26
U_1 UPLAND SANDSTONE	Weathered -poorly lithified sandstone no rock fragments	8-15%	70	2-6	0.20
U_2 UPLAND SILTSTONE	Lacustrine units-silts & mudstone sandy facies	8-18%	40	0.2-0.6	0.73
U_3 CLINKER UPLAND	Clinker fractured resistant	15-20%	70-80	2-4	0.17
U_4 STEEP UPLAND UNIT	Fractured hard sandstone & siltstone w/ some massive formations	30%	70-80	4-6	0.22

The silty valley bottom unit is characterized by a low density of drainage lines (despite low surficial infiltration rates), apparently due to the destruction of channels by cultivation. As a consequence, the existing channel network may be inadequate to conduct runoff from this unit. To adjust, the network will tend to expand by entrenchment, resulting in increased sediment yields. This unit may, therefore, be potentially unstable. Sediment yields from the other landscape units in the permit area are estimated to be low, reflecting high infiltration capacities, resistant surficial materials, and a dense vegetative cover on these components.

East Fork Armells Creek and Stocker Creek both reflect strong bedrock and structural control (by faulting) on drainage basin and stream network development. This influence is strongest in the headwaters of these creeks and decreases downstream. Sediment yield from subbasins of these drainages is generally low, reflecting the high infiltration rate and the relative inefficiency of the vegetated ephemeral streams in transporting sediment. A discussion of the sedimentation rates and the method of calculation is presented in the Technical Support Document to this EIS (available at the Department of State Lands office, Helena). The main channels within the basins are generally stable, while the smaller, ephemeral channels usually have reaches that are actively being deepened or filled in.

2.1.2 Stratigraphy

Quaternary deposits consist of weathered bedrock, colluvium, and unconsolidated clay, silt, and sand alluvium. In the five-year mine plan area, clinker deposits (locally known as scoria) have formed at and above the burned coal outcrop. Alluvial gravels are present in the East Fork Armells Creek Valley. Alluvium, colluvium, and clinker all constitute porous, near-surface aquifers of limited potential volume.

The Wasatch Formation has been removed by erosion in the Rosebud Mine area, and the only rock unit outcropping is the Tongue River Member of the Fort Union Formation. This member is predominantly a fine- to medium-grained silty sandstone with interbedded siltstone, silty shale, carbonaceous shale, localized clinker deposits, and coal beds. Pederson (Western Energy, 1981) states that the total thickness of the Fort Union Formation at Colstrip is 445 feet, with at least the top 360 feet being the Tongue River Member. Three coal seams in this member, in descending stratigraphic order, are the Rosebud, McKay, and Stocker. The coals dip generally one to two degrees southerly, with many local variations in the mine area as a result of small-scale folding, faulting, and localized thinning and thickening of coal seams and interburden.

2.1.3 Overburden

The overburden in the Rosebud Mine area is composed of interbedded sandstone, siltstone, shale, and clinker, with various degrees of gradation between the units. Geochemical analyses of samples collected from drill holes in the overburden are presented in table form in Western Energy

Company's Comprehensive Mine Plan. The location of overburden test holes is shown in Figure 2.1-2.

The overburden material was tested for 18 characteristics (Western Energy Company Comprehensive Mine Plan, 1981). Seven of the 18 characteristics showed values exceeding current (1977) Department of State Lands suspect levels: electrical conductivity (a measure of salinity), molybdenum, cadmium, lead, nickel, zinc, and sand. Suspect levels are the points at which revegetation and post-mining land use may be adversely affected if material exceeding these levels is placed at the surface or in the rootzone. (See Table 1, Appendix A. for description of DSL suspect levels).

Elevated zinc and iron values are probably the result of contamination from zinc- and lead-based drillstem lubricants; thus the values probably do not accurately represent lead and zinc levels in the overburden. However, even if it is assumed that these elevated values are representtative of the overburden material, no toxicity problems are anticipated. (See section 3.1.3) The remaining five characteristics are shown graphically in Table 2.1-2 by percentage of samples in each overburden hole that exceed State suspect levels in Area C. These holes and overburden characteristics are typical and representative of the Rosebud Mine area, though molybdenum and sand concentrations are generally higher in Area B.

2.1.4 Aquifers

Aquifers in the mine area include alluvial and colluvial deposits, Tongue River Member sandstones and coals, Lower Fort Union sandstones, and the lower Hell Creek-Fox Hills Sandstone (considered a single aquifer). In the mine area, only those aquifers above the McKay coal seam would be physically disturbed. A description of these aquifers is presented in Section 2.2, Hydrology.

2.1.5 Structure

The proposed mine area lies entirely within the northwestern portion of the Powder River Basin, a large depositional basin extending east into South Dakota, south into Wyoming, and over 30 miles west and north of Colstrip. Superimposed upon this northwest flank of the Powder River Basin are numerous smaller scale structures, including the Ashland syncline, a west-northwest-trending shallow structural trough that cuts the southwest quarter of T1N, R40E. The axis of this syncline roughly coincides with the southwestern limit of the proposed mining area as shown in Western Energy's Comprehensive Mine Plan, Exhibit C (1981) (see Surficial Geology Map in the Technical Support Document).

In other sectors of the Rosebud Mine, several faults have been mapped and/or inferred from aerial photos. These faults have a strong west-northwest trend paralleling the Ashland syncline axis.

Comparison of cross sections from Western Energy's Comprehensive Mine Plan (1981) with faulting mapped and inferred by the USGS (Lewis and

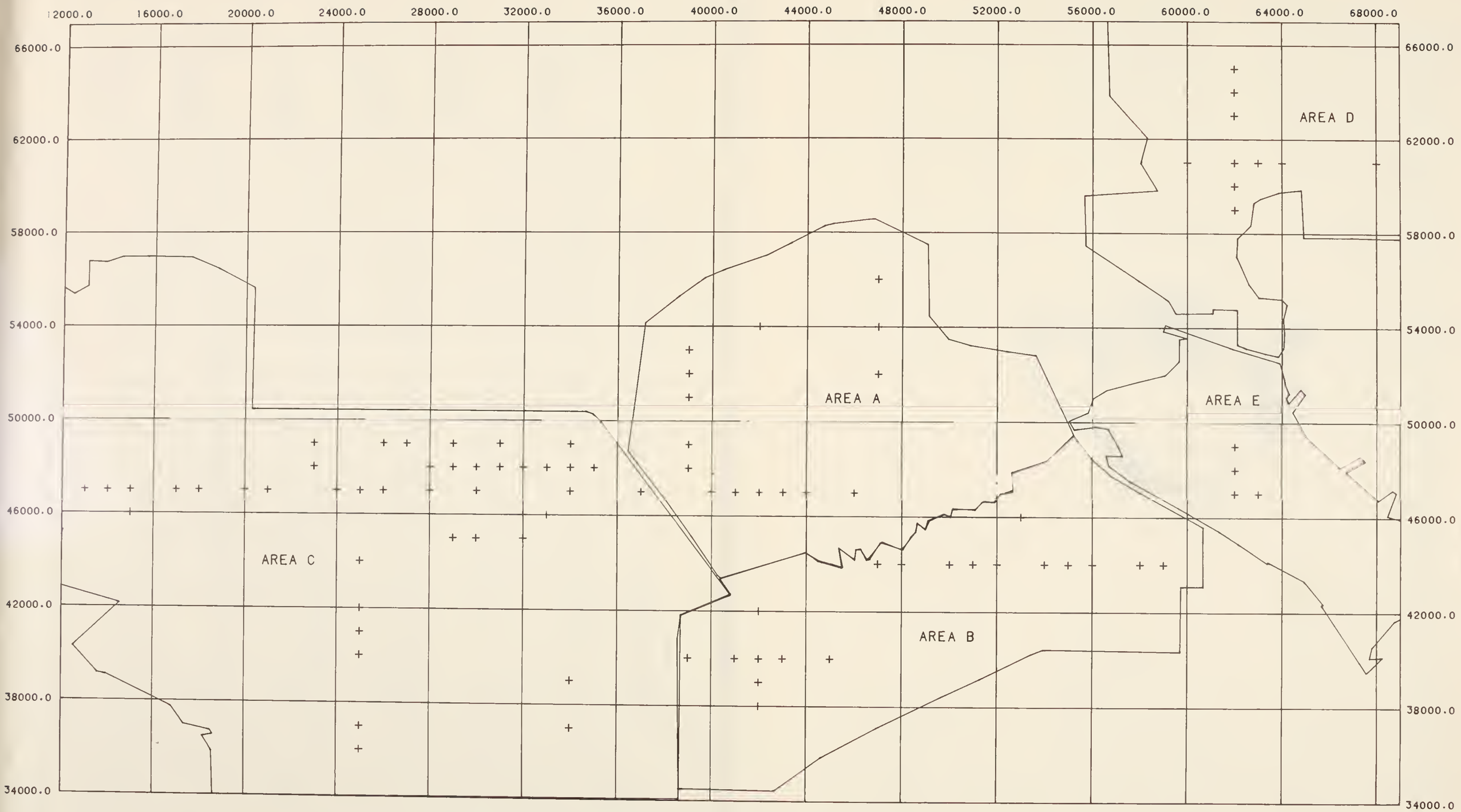


FIGURE 2.1-2 OVERBURDEN GEOCHEMISTRY HOLE LOCATIONS, ROSEBUD MINE

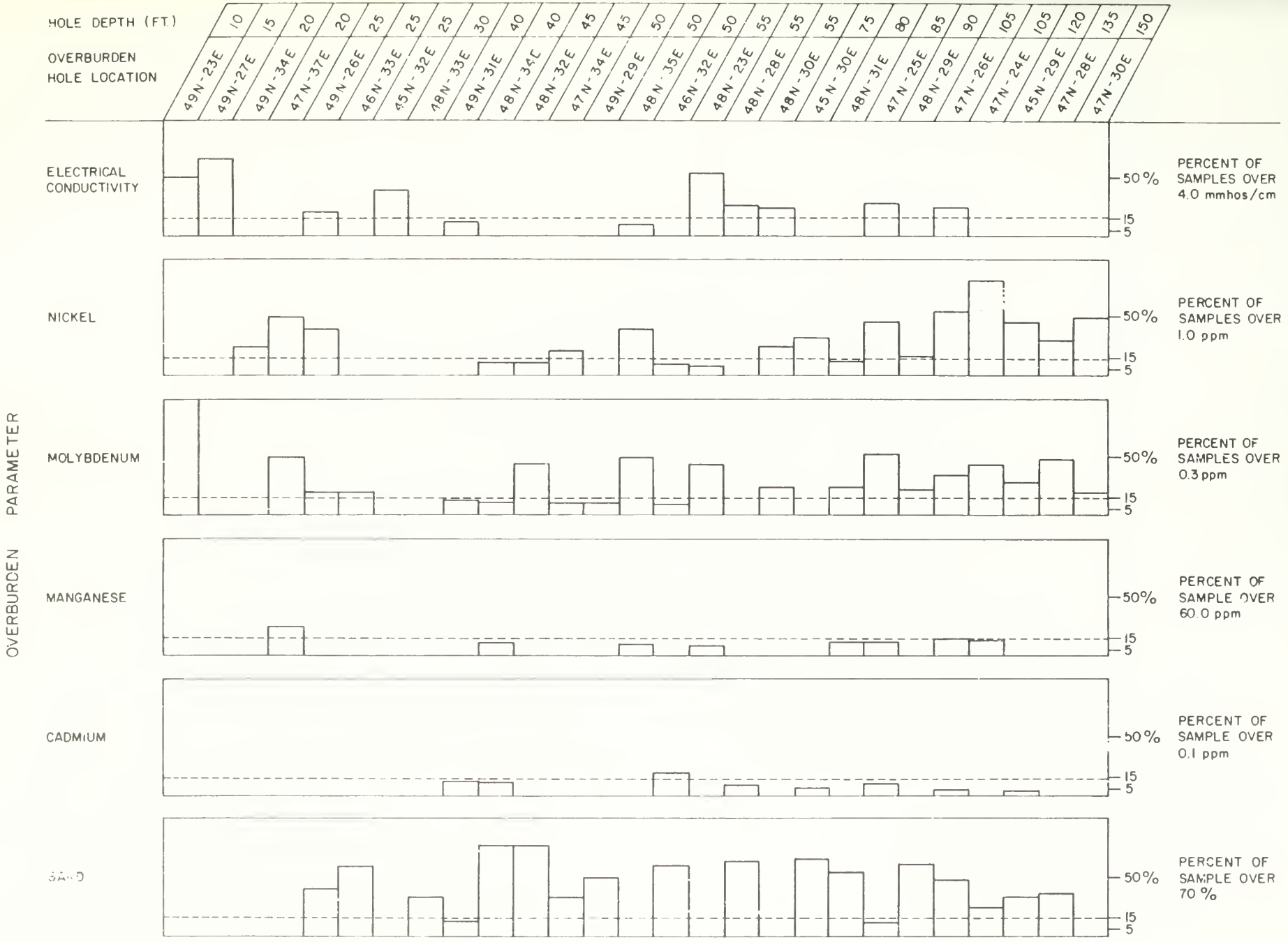


TABLE 2.1-2 PERCENTAGE OF SAMPLES EXCEEDING STATE SUSPECT LEVELS IN OVERBURDEN TEST HOLES, ROSEBUD MINE, MONTANA

Roberts, 1978) in the mine area appears to confirm the presence of the faults shown on the surficial geology map in the Technical Support Document.

2.1.6 Geologic Hazards

No known significant geologic hazards exist in the proposed mine area. No active faulting is evident, and the entire northern Powder River Basin is tectonically stable.

2.1.7 Paleontology

Fossil leaves and invertebrates of the Paleocene Period are abundant throughout the Fort Union Formation and are likely to be in the proposed mine. However, these are all common fossils and have limited scientific significance. No significant vertebrate fossils are known to occur in the Fort Union Formation (Taylor, 1975; U.S.D.I., 1978). There are no known fossil collecting sites in the mine permit area.

2.1.8 Resources

Natural resources in the Northern Powder River Basin include coal, oil, gas, uranium, sand, gravel, and some clay. Of these, coal is by far the most important.

Oil and gas exploration is now active in Rosebud County, but no oil or gas has been discovered near the Rosebud Mine. The nearest oil and gas production is in the Hardin field, 36 miles to the west, where gas is produced from the Middle Cretaceous Frontier Formation. The nearest oil production to Colstrip is 48 miles north on the Porcupine Dome.

No known or indicated reserves of uranium lie in the Rosebud Mine area. Sand, gravel, and some clay are present in minor amounts. Clinker deposits along the burned coal outcrop have been used for road gravel in the past.

Of the six coal seams underlying the Rosebud Mine area, only the uppermost two, the Rosbud and the McKay, are minable by surface mining technology. Western Energy has not been able to market coal from the McKay seam, and so proposes to mine only the Rosebud seam. Western Energy (1981, v. 1, pp. 18-21), cites the McKay seam's relatively high production costs and low quality, excess industry production capacity and a depressed coal market as the major factors limiting the marketability of McKay seam coal.

Western Energy expects to recover approximately 377 million tons of coal from the Rosebud Mine by 2017. (See Table 2.1-3.)

TABLE 2.1-3

PROJECTED PRODUCTION AT THE ROSEBUD MINE, 1980-2017

AREA	YEARS	MILLION TONS	TOTAL MILLION TONS
A	1980-1984	8.0	
	1985-1989	20.0	
	1990-1994	9.6	37.6
B	1980-1984	24.0	
	1985-1989	20.0	
	1990-1994	30.4	74.4
C	1983-1987	25.0	
	1988-1992	30.0	
	1993-1997	30.0	
	1998-2002	25.0	
	2003-2007	25.0	
	2008-2012	25.0	
	2013-2017	25.0	185.0
D	1980-1984	4.0	
	1985-1989	20.0	
	1990-1994	20.0	
	1995-1999	20.0	
	2000-2004	4.0	68.0
E	1980-1984	11.7	11.7
	PROJECTED TOTAL RECOVERABLE -		376.7

2.2 HYDROLOGY

The following section discusses groundwater and surface water systems on a regional scale. The data considered are specific to the area surrounding the Rosebud Mine. Figure 2.2-1 shows the general hydrologic setting and illustrates the drainages and coal seam outcrops*/subcrops* examined during the preparation of this EIS.

The purposes of this section are to identify flow characteristics, describe the existing quality and usage of both surface water and groundwater systems, and to identify the relationship between surface and groundwater throughout the hydrologic study area.

Information on the hydrology of the Rosebud Mine area was obtained from (1) Western Energy Company's records on groundwater, surface water, and water quality; (2) published reports and ongoing studies by the Montana Bureau of Mines and Geology, the United States Geological Survey (USGS), and the U.S. Environmental Protection Agency (EPA); and (3) recent EIS's, Montana Power Company reports, State documents, Peabody Coal Company records, and Montana State University Agricultural Experiment Station research documents.

2.2.1 Groundwater

The discussion on groundwater includes:

- The physical and hydraulic properties of each water-bearing unit
- The characteristics of groundwater flow in each unit aquifer
- Groundwater quality
- Groundwater use

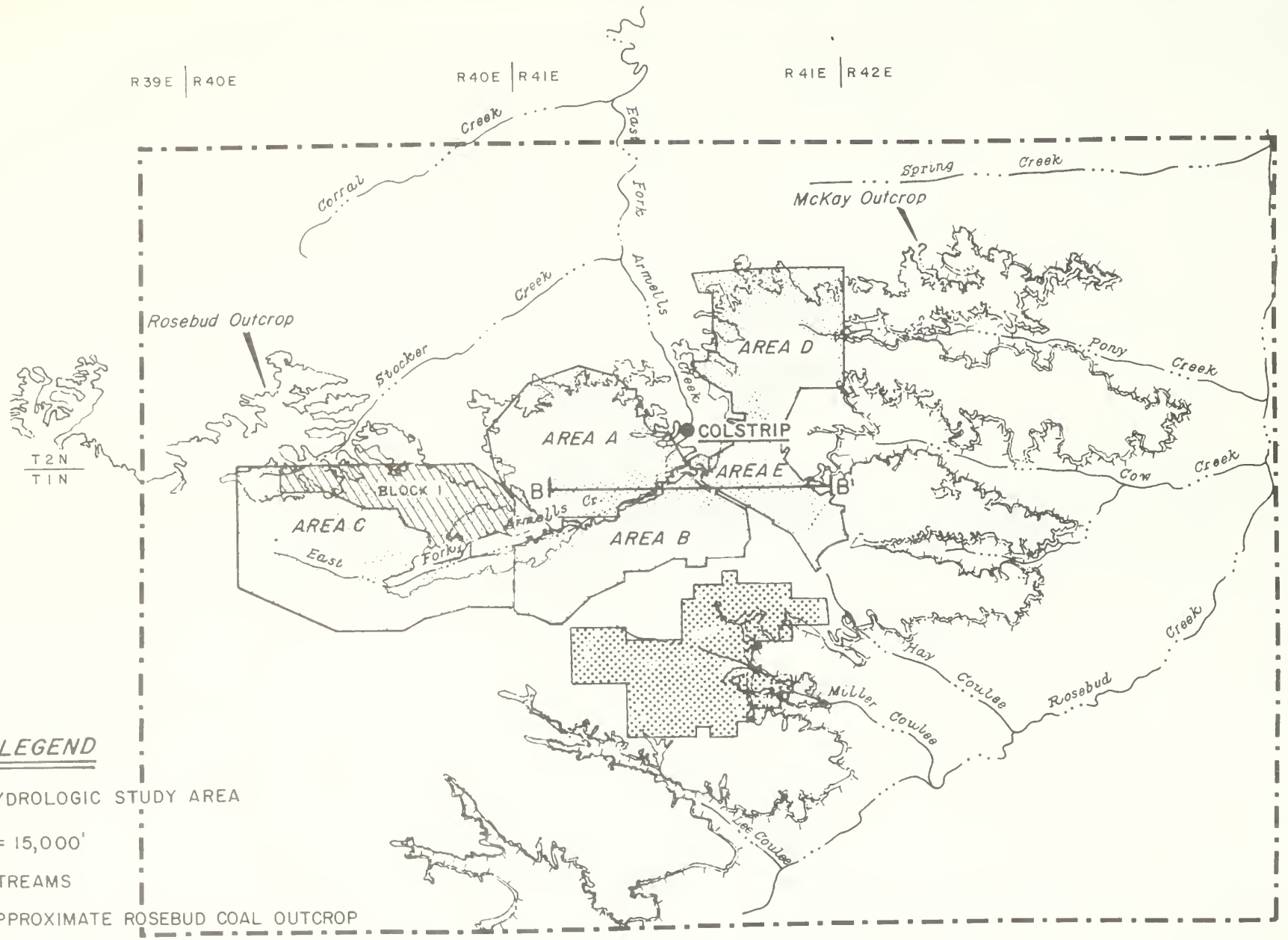
2.2.1.1 Water-bearing Strata

Groundwater and geologic studies (Section 2.1.2) have identified seven near-surface geologic units in the Rosebud Mine area that can store and transmit water (Figure 2.2-2):

- Rosebud spoils*
- Valley fill material*
- Rosebud coal overburden*
- Rosebud coal
- Rosebud/McKay interburden*
- McKay coal
- Sub-McKay

---

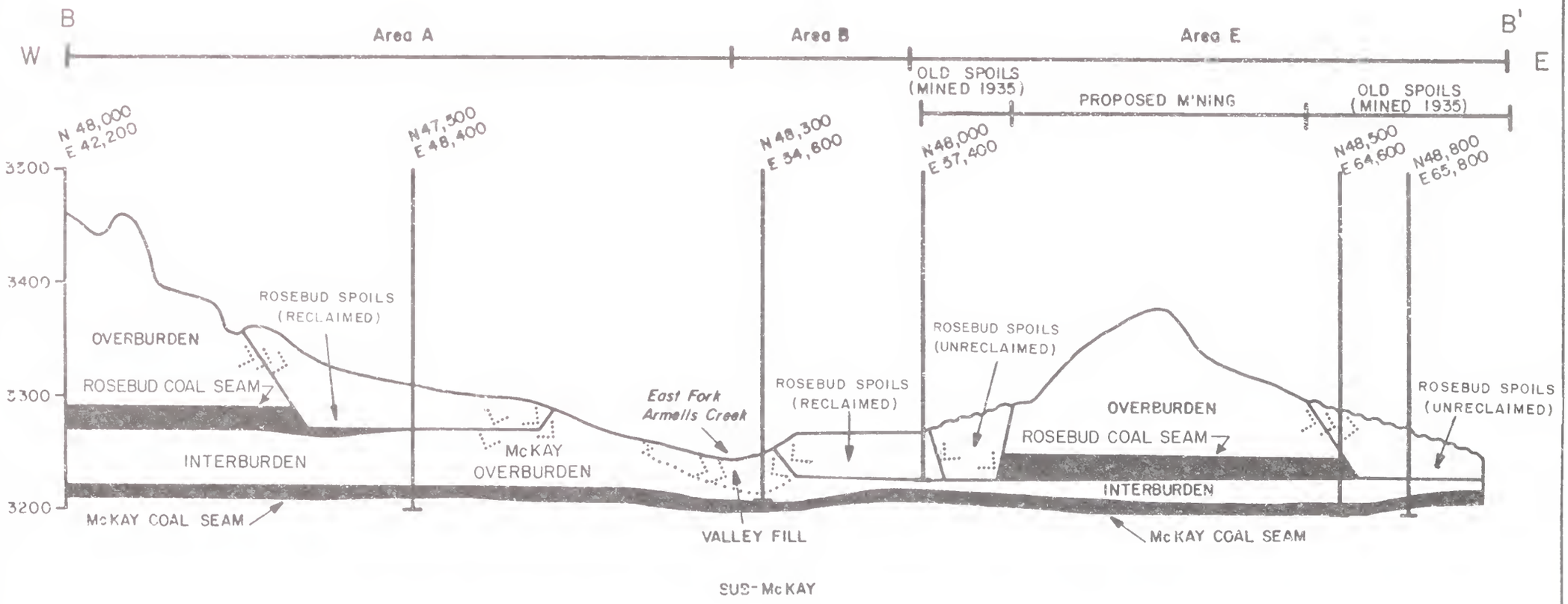
* Indicates the first appearance of a term defined in the Hydrology Glossary at the end of this section.



LEGEND

- HYDROLOGIC STUDY AREA
- SCALE 1" = 15,000'
- STREAMS
- APPROXIMATE ROSEBUD COAL OUTCROP
- APPROXIMATE McKAY COAL SUBCROP/OUTCROP
- B — B' LOCATION OF FIGURE 2.2-7, CROSS SECTION OF SPOILS AND SURROUNDING MATERIAL
- ROSEBUD MINE AREAS
- BIG SKY MINE - AREA A - 2/4/82
- BLOCK I SITE-SPECIFIC STUDY AREA

FIGURE 2.2-1 HYDROLOGIC STUDY AREA SHOWING DRAINAGES WITH APPROXIMATE COAL SEAM OUTCROPS/SUBCROPS



LEGEND

HORIZONTAL SCALE: 1"= 2790'

VERTICAL SCALE: 1"= 143'

VERTICAL EXAGGERATION: 20X

DIRECTION OF GROUNDWATER MOVEMENT

SEE FIGURE 2.2-1 FOR LOCATION OF CROSS SECTION B-B'

FIGURE 2.2-2 SCHEMATIC CROSS SECTION OF GROUNDWATER MOVEMENT THROUGH SPOILS AND SURROUNDING MATERIAL, ROSEBUD MINE AREA, MONTANA

In order of diminishing importance (defined as the number of wells completed), these are--

Sub-McKay
Rosebud Overburden
Rosebud Coal
Valley-Fill-McKay Coal

In general, the properties identified for each water-bearing unit in the following descriptions are considered to be consistent throughout the hydrologic study area.

2.2.1.1.1 Rosebud Spoils

The Rosebud spoils consist of excavated Rosebud coal overburden material that has been replaced where the Rosebud coal has been mined out. Since the dragline deposits spoils in rows parallel to the stripping operation, spoils exhibit higher permeability* in the direction of the dragline movement. Due to the linear placement of the spoils, permeability* values also vary with direction. Data from aquifer* tests in the spoils indicate that the mean transmissivity* of the spoils is 2,000 gallons/day/ft (gpd/ft), with a median transmissivity value of 61 gpd/ft, and a range of transmissivity values from less than 1 to 23,400 gpd/ft (see Table 2.2-1).

Rosebud spoils in previously mined areas vary in thickness from less than 1 foot near the coal outcrop to over 120 feet in Rosebud Mine Areas A and B. A more permeable rubble zone has been noted (Van Voast et al., 1978) at the base of the spoils. This zone consists of waste coal and larger rock fragments that roll to the bottom during spoils replacement. According to Van Voast et al. (1978), the rubble of boulders and wasted coal at the base of the spoils is probably responsible for the large range of transmissivity values. Generally, however, Van Voast found that hydraulic conductivity* values for the spoils were similar to the values of the aquifers replaced.

2.2.1.1.2 Valley Fill Material

The materials making up the valley fill system consist of alluvial* and colluvial* deposits. These deposits comprise interbedded silts, sands, gravels, and clays and are generally less than 40 feet thick. In the Rosebud Mine area valley fill material lies in stream bottoms and on terraces* situated about 10 to 20 feet above the stream bottoms. Colluvial and alluvial material intermingle where the hillsides merge with the alluvial terraces.

The large range of particle sizes, from boulder-size colluvial fragments to clay-size particles in the alluvial deposits, along with the lenticular shape of the valley fill deposits, has an effect on the groundwater flow in this system. These lenses of alluvial material result in zones of variable hydraulic conductivity. Table 2.2-1 lists the available transmissivity and hydraulic conductivity values for the wells tested in

TABLE 2.2-1

SUMMARY OF TRANSMISSIVITY AND HYDRAULIC CONDUCTIVITY VALUES
FOR AQUIFER TESTS IN THE ROSEBUD MINE AREA

	TRANSMISSIVITY				HYDRAULIC CONDUCTIVITY			
Aquifer	Number of Aquifer Tests	Range of Values (gpd/ft)[1]	Mean Value (gpd/ft)	Median Value (gpd/ft)	Number of Values Used in Analysis[2]	Range of Value (ft/day)[3]	Mean Value (ft/day)	Median Value (ft/day)
Rosebud Spoils	17	0.24-23,400	2,000	61	17	0.001-65.3	6.020	0.3
E. Fork Armells Valley Fill	25	6.0-74,800	12,600	9,900	23	6.4-501.3	119.500	102.5
Stocker Cr. Valley Fill	6	2,200-50,000	18,900	5,300	--	--	--	--
Cow Creek Valley Fill	4	190-49,500	(Increased downstream)		4	60-2,800	2,600 (midreach)	--
Rosebud Coal Overburden	23	1.0-79,000	8,950	57	12	0.006-3.8	0.468	0.015
Rosebud Coal	35	3-12,700	526	30	35	0.005-68	5.170	0.120
McKay(a) Overburden	9	230-2,600	1,500	570	--	--	--	--
Rosebud/McKay Interburden	11	1.0-20	64	6	8	0.002-0.9	0.150	0.014
McKay Coal	19	1-1,410	10	7	18	0.002-3.6	0.724	0.150
Sub-McKay	6	90-3,200	860	470	--	--	--	

-- no data available.
1. gallons per day per foot.
2. conductivity values were not calculated for all aquifer tests because of lack of informtaion.
3. feet per day.
(a) McKay overburden - Rosebud coal does not exist above the McKay coal unit.

the study area. Most of the valley fill aquifer tests were performed along East Fork Armells and Stocker Creek drainages.

Botz (1979) and Van Voast (1977) state that storage coefficients ranging from 0.1 to 0.3 are typical for the valley fill material. Transmissivities for the East Fork Armells Creek valley fill range from 6 to 74,800 gpd/ft for 25 tests. The mean and median transmissivity values are both approximately 10,000 gpd/ft.

The valley fill material in Stocker Creek appears to consist of the same material present in East Fork Armells Creek but exhibits a narrower range of transmissivity values (2,200 to 50,000 gpd/ft). Only six aquifer tests have been conducted in the Stocker Creek drainage.

The mean and median values for transmissivity and hydraulic conductivity (Table 2.2-1) are higher for the valley fill aquifer than for other water-bearing strata underlying the area. This is due to the coarse-grained texture of some of the valley fill materials.

2.2.1.1.3 Rosebud Coal Overburden

Rosebud coal overburden throughout the area overlies the Rosebud coal and is composed of brown to gray very fine to medium-grained sand, shale, claystone, and clinker*. Overburden thickness varies from zero at the Rosebud coal outcrop/subcrop to over 240 feet beneath the sandstone ridges in Area C. The sandstone, shale, and claystone are interbedded and discontinuous; therefore, the ability of the aquifer to transmit water varies from well to well.

The overburden is generally considered to be an unconfined* aquifer, although in some areas it does show confined* characteristics. Twenty-three aquifer tests conducted in the Rosebud overburden indicated a range of transmissivity values from 1 to 79,000 gpd/ft. The mean (8,950 gpd/ft) and median (57 gpd/ft) values vary by approximately 8,900 gpd/ft. This wide variation in transmissivity may be due to the variability of the lithologic units in the overburden (Geology, Section 2.1.3). Flexures and fracturing in the overburden in Area B (Plate B-1, Technical Support Document) could be responsible for the high transmissivity values (79,000 gpd/ft) in that area.

In some areas, the overburden includes clinker, which is usually brittle and highly fractured. According to Dollhopf (1978), fractures in the clinker create areas of potential groundwater recharge or discharge.

2.2.1.1.4 Rosebud Coal

The Rosebud coal varies in thickness from zero at the outcrop to approximately 26 feet, and has an average thickness of 23 feet. The coal is locally fractured and folded, resulting in localized zones of high porosity* and permeability.

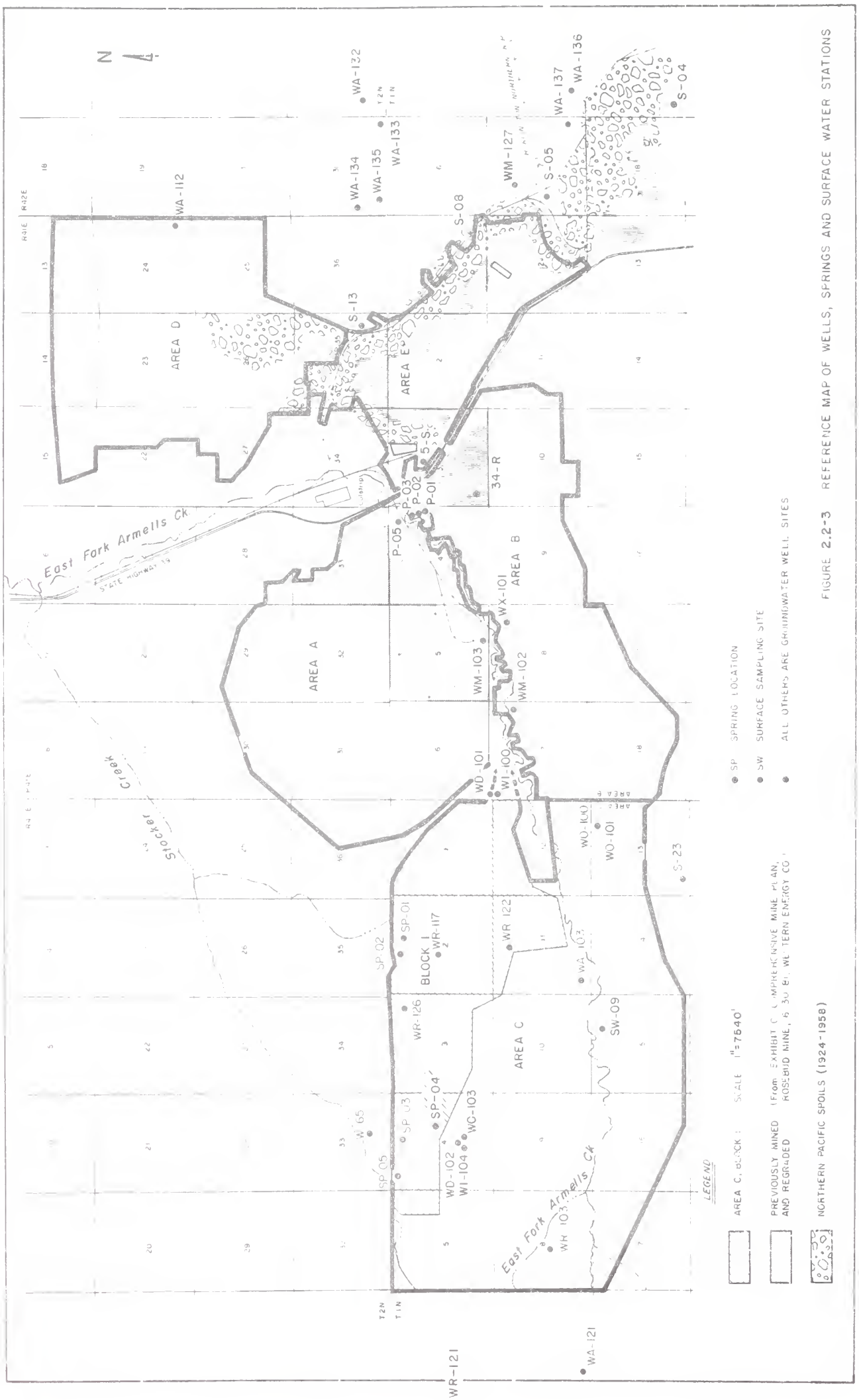


FIGURE 2.2-3 REFERENCE MAP OF WELLS, SPRINGS AND SURFACE WATER STATIONS

The Rosebud coal aquifer is confined over the mine area, except where it crops out or subcrops. A broad range of transmissivity values has been calculated for the Rosebud coal. The transmissivity calculated from 35 tests range from 3 to 12,700 gpd/ft. The mean transmissivity is 526 gpd/ft, and the median value is 30 gpd/ft. The wide range is probably the result of the inconsistent fracture pattern of the coal bed. The ability of the aquifer to transmit water is directly proportional to the degree of fracturing in the coal.

A constant discharge test of the Rosebud coal aquifer was conducted at well 34-R, 1 mile south of Colstrip (Figure 2.2-3), where two observation wells were monitored. The storage coefficient was calculated to be about 0.000015, which is within the typical range of 0.00001 to 0.001 for confined aquifers.

2.2.1.1.5 Rosebud/McKay Interburden

Within the Rosebud Mine area, the Rosebud and McKay coal seams are separated by 10 to 100 feet of interburden, but the typical interburden thickness varies from 40 to 60 feet. The interburden consists of clays and shales interbedded with sandstone lenses. The interburden contains more clay than the overburden and is considered to be a less productive water-bearing stratum. However, fractures and lithologic changes in the interburden may allow some exchange of groundwater between the Rosebud and McKay aquifers in some areas. Lithologically, the McKay overburden and interburden are the same: the McKay overburden is simply the interburden where the Rosebud coal seam has been eroded away. (See Figure 2.2-2.)

The interburden between Rosebud and McKay coal seams is a confined aquifer and exhibits a mean transmissivity of 43 gpd/ft and a median transmissivity value of 7 gpd/ft. The range of transmissivity values (1 to 2.0 gpd/ft) is the lowest for any of the aquifers. Some fractures and faulting have caused anomalously high transmissivity values, but as a unit, the clays and shales characteristic of the interburden appear to be responsible for inhibiting the groundwater flow through this aquifer. The McKay overburden is an unconfined aquifer* with transmissivities that range from 230 to 2,600 gpd/ft, with a median of 570 gpd/ft and mean of 1,500 gpd/ft. These values are higher than those for the interburden, indicating a difference in hydrologic characteristics.

2.2.1.1.6 McKay Coal

The McKay coal is approximately 8 to 12 feet thick in the Colstrip area and exists over most of the area, as shown in Figure 2.2-1. The McKay coal is a confined aquifer in the Rosebud Mine area, and its porosity and permeability stem from fracturing. According to Van Voast (1977), storage coefficients for both the Rosebud and McKay aquifers are within the same range (0.00001-0.0001). However, the transmissivity of the McKay coal aquifer ranges from 1 to 560 gpd/ft (24 tests), considerably lower than the range for the Rosebud coal aquifer.

2.2.1.1.7 Sub-McKay

The regional sub-McKay aquifer consists of sandstone and sandy clays in the Tongue River Member of the Fort Union Formation. The sub-McKay unit underlies the McKay coal and ranges from 20 to 250 feet beneath the surface in the Rosebud Mine area. The Lebo Shale Member of the Fort Union Formation forms a widespread, essentially impermeable base to the sub-McKay unit.

Available information indicates that the sub-McKay is a confined aquifer system. Transmissivity values calculated from six aquifer tests in the sub-McKay range from 90 to 3,200 gpd/ft, with a mean of 860 gpd/ft and a median of 470 gpd/ft.

2.2.1.2 Groundwater Flow

The following section will discuss groundwater flow in the hydrologic study area. Flow will be defined by: 1) focusing on the direction of flow within each water-bearing stratum; 2) identifying the way significant quantities of water move between aquifers; and 3) discussing where and how groundwater recharge and discharge occur.

Before proceeding with the discussions outlined above, there are some important overall trends in groundwater flow that should be summarized:

- Significant bedrock groundwater flow exists in the Rosebud and McKay coal seams. Flow velocities are low but are higher than in the Rosebud overburden and Rosebud/McKay interburden.

- Bedrock flow is generally to the east. Deviations in regional flow patterns occur in the vicinity of mine pits, in areas of structural highs and lows, and where coal seams crop out and subcrop.

- Some bedrock discharge occurs along upper East Fork Armells Creek; however, just above Colstrip the valley fill along East Fork Armells Creek recharges bedrock.

- Flow in spoils and valley fill originates either by direct infiltration of precipitation or by inflow from bedrock.

- Flow directions in spoils are highly dependent upon the placement of spoils and cannot be easily generalized.

- Flow direction in the valley fill is generally parallel to the direction of the stream channel.

- Minor deviations in flow direction in valley fill material result from the recharge-discharge relationship with bedrock aquifers, the seasonally controlled amount of net infiltration (from precipitation), and an influx of water to the valley fill from a leaking surge pond downstream from Colstrip.

2.2.1.2.1 Nature of Flow Within Water-Bearing Strata

The seven water-bearing strata are either confined or unconfined and have varying flow directions. Generally, aquifers of regional extent, such as the Rosebud coal aquifer, flow from the northwest to southeast. However, less extensive strata (such as spoils, valley fill, and to some extent the Rosebud coal overburden) have a less uniform flow direction.

The following discussion summarizes flow characteristics in each of the seven water-bearing strata.

Rosebud Spoils

The inflow and outflow of spoils groundwater is illustrated schematically in Figure 2.2-2. The groundwater in the spoils is generally unconfined; however, some evidence suggests that water may be confined in the lower portion of the spoils unit.

Figure 2.2-4 is a potentiometric map of the Rosebud spoils aquifer.

Variations in flow direction within the Rosebud spoils are due to the different sources of recharge and discharge.

Valley Fill Material

Groundwater flow in the valley fill system generally parallels the stream channel, as indicated in Figure 2.2-5. Water levels decline in summer when evapotranspiration is high and precipitation is low. During winter months, when evapotranspiration is minimal, water levels tend to rise. The flow within valley fill is affected by the recharge and discharge relationships between the valley fill and surrounding bedrock.

Rosebud Coal Overburden

The large variability in overburden lithology makes it difficult to construct a meaningful potentiometric map for the overburden. The general gradient of water in the overburden appears to follow the structural gradient of 0.5 to 1 percent to the southeast. Groundwater is not laterally continuous throughout the overburden, but where there is a saturated condition, the groundwater may be either confined or unconfined. The source of water in the overburden is probably direct infiltration of precipitation or downward percolation of alluvial groundwater. Limited seepage may occur at locations where the overburden has been cut by mining or where it crops out. Localized depression of the groundwater surface in the overburden near open pits has been observed by Dollhopf et al. (1978) in Area B. The same phenomena will occur in all open pits due to seepage.

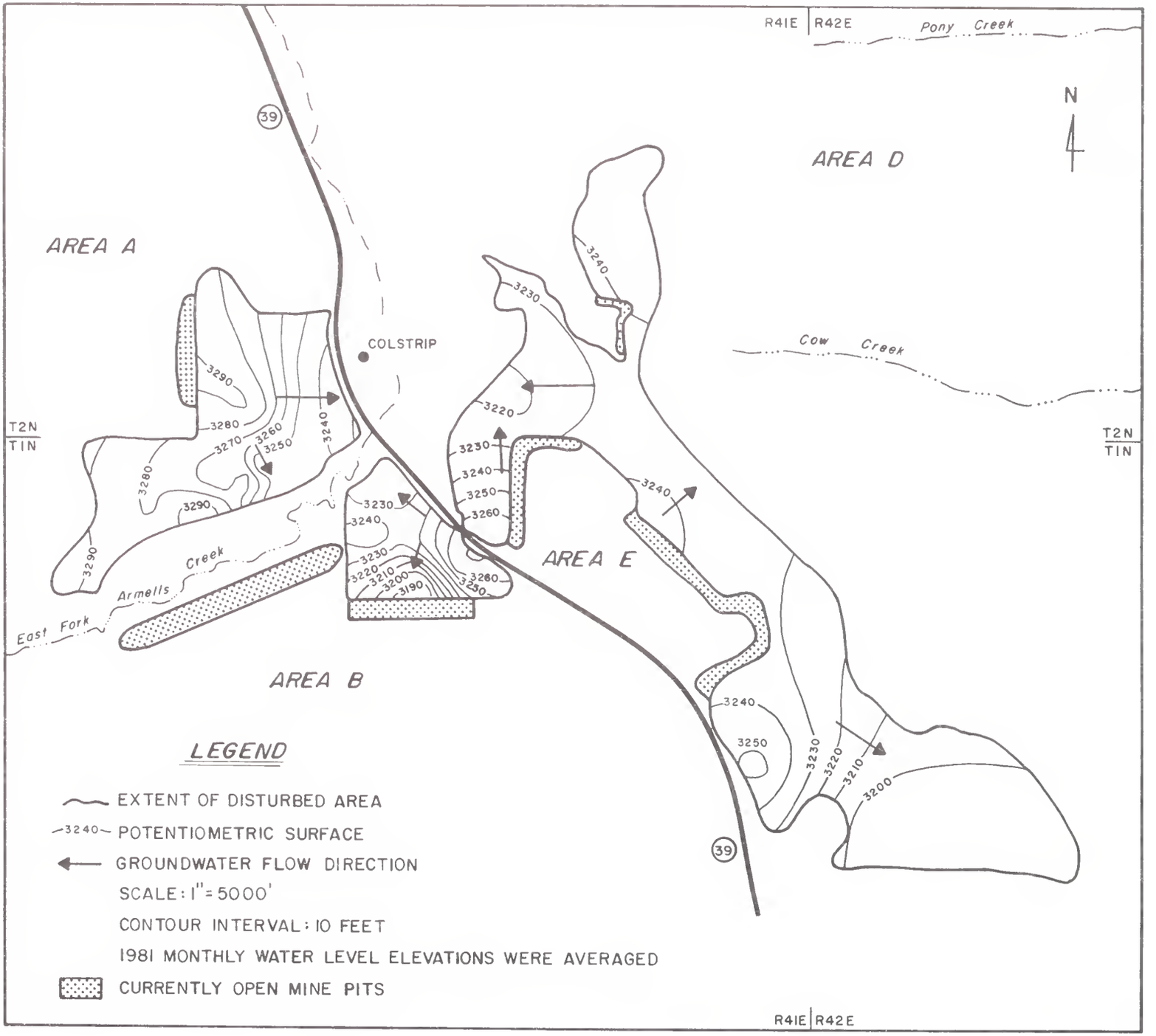


FIGURE 2.2-4 POTENTIOMETRIC SURFACE OF SPOILS AQUIFER, ROSEBUD MINE, MONTANA

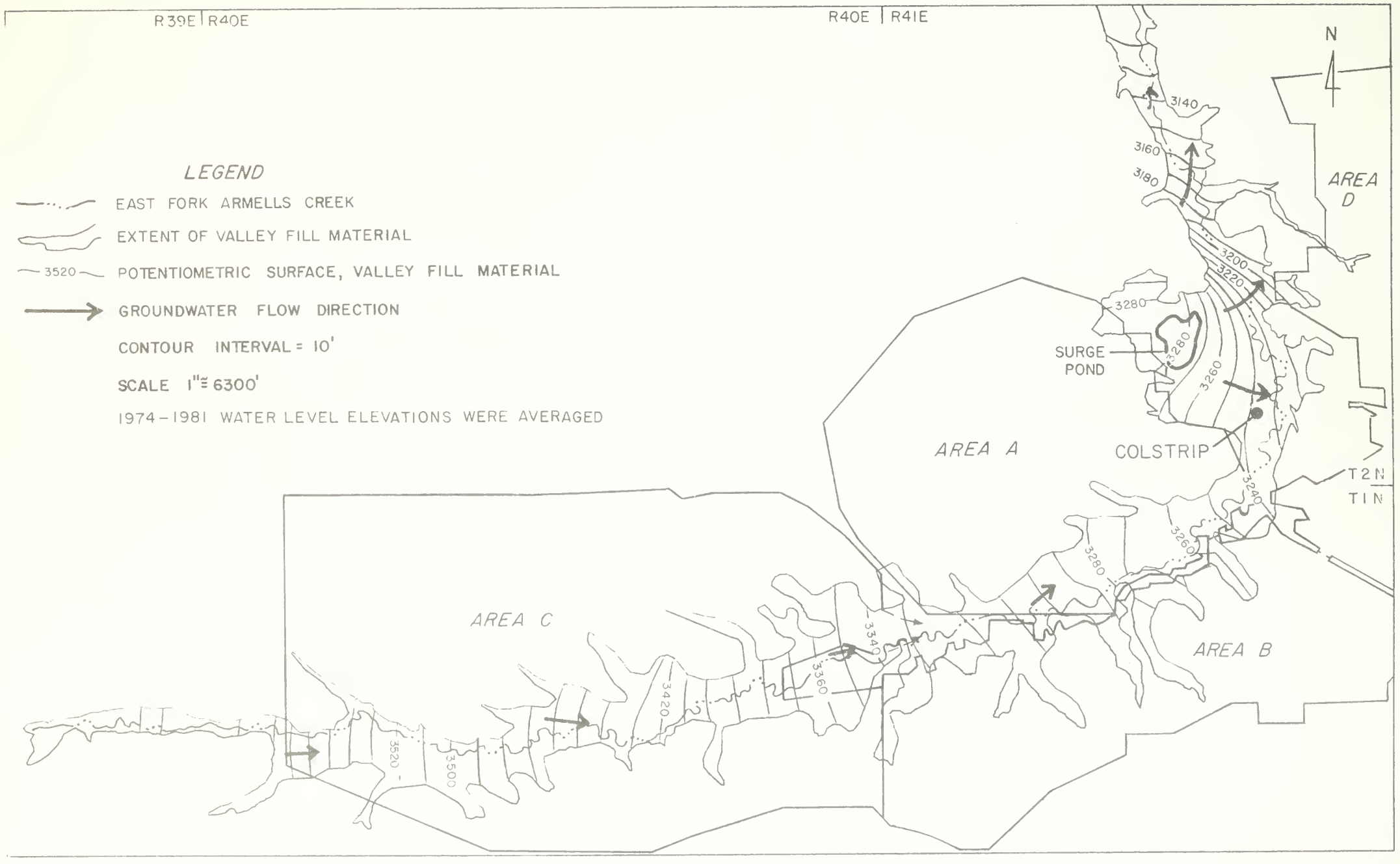


FIGURE 2.2-5 POTENTIOMETRIC SURFACE MAP OF VALLEY FILL AQUIFER
ROSEBUD MINE, MONTANA

Rosebud Coal

The direction of groundwater flow within the Rosebud coal aquifer is illustrated in Figure 2.2-6. Regional flow originates west of the mine and moves eastward, except where affected by previous mining. The hydraulic gradient in the Rosebud coal aquifer follows the structural dip of the unit. Local depressions of the Rosebud potentiometric surface occur near open pits and recently spoiled areas. These changes in the groundwater flow patterns are not shown in Figure 2.2-6, since it represents a generalized potentiometric surface. Figures 3.2-1 to 3.2-3 in the impact section show predicted drawdowns in the Rosebud aquifer due to mining through time.

Flow is not continuous from Area C to Area A, because water in Area C discharges to the north (Stocker Creek) and to the southeast (East Fork of Armells Creek). As a result, very little (if any) water flows out of the Rosebud coal under Area C into Area A. (See Figure 2.2-6.) Further, the western edge of Area A is essentially dry. Similarly, groundwater flow from Area A does not flow to Area E. Instead, it discharges to East Fork Armells Creek.

Groundwater in the extreme southern portion of Area C and Area B is on the opposite side of a groundwater divide from the rest of the Rosebud Mine. Flow there moves to the southeast toward the Big Sky Mine and the tributaries of Rosebud Creek (Hay, Coal Bank, Emilee, and Miller Coulees). In contrast, groundwater in the part of Area C located between East Fork Armells Creek and the groundwater divide, in addition to most of Area B groundwater, flows eastward and northeastward. This flow now enters the East Fork Armells Creek alluvium or open mine pits. Similarly, groundwater in the Rosebud seam of Area E flows primarily northeast, entering existing mine spoils and open mine pits. Flow in Area D is primarily to the south, toward Cow Creek.

Conditions in the Rosebud coal aquifer vary from confined to unconfined, as shown in Figure 2.2-7, where the bedrock is apparently faulted and fractured. It is possible that the faulted area provides an excellent conduit for vertical groundwater flow.

Rosebud/McKay Interburden

Flow in the Rosebud/ McKay interburden is probably largely confined, except where the Rosebud coal has been eroded. The regional direction of flow is probably structurally controlled (i.e., northwest to southeast). Water occurring in the interburden probably comes from minimal leakage downward from the Rosebud coal.

McKay Coal

Figure 2.2-8 shows the regional flow in the McKay coal aquifer. Flow directions are very similar to those observed for the Rosebud coal aquifer.

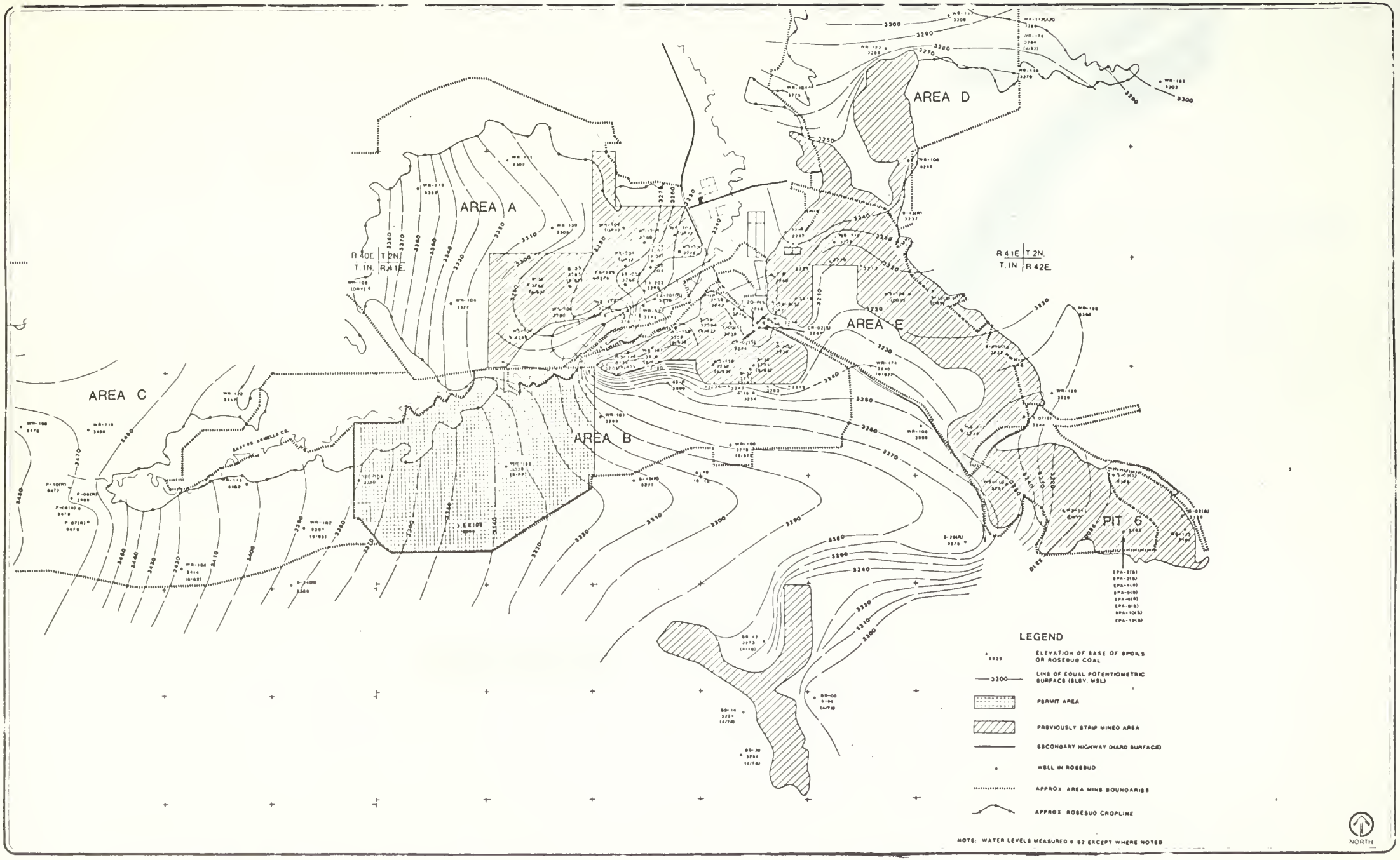


FIGURE 2.2-6 REGIONAL POTENTIOMETRIC SURFACE OF ROSEBUD COAL AQUIFER, ROSEBUD & BIG SKY MINES, MONTANA

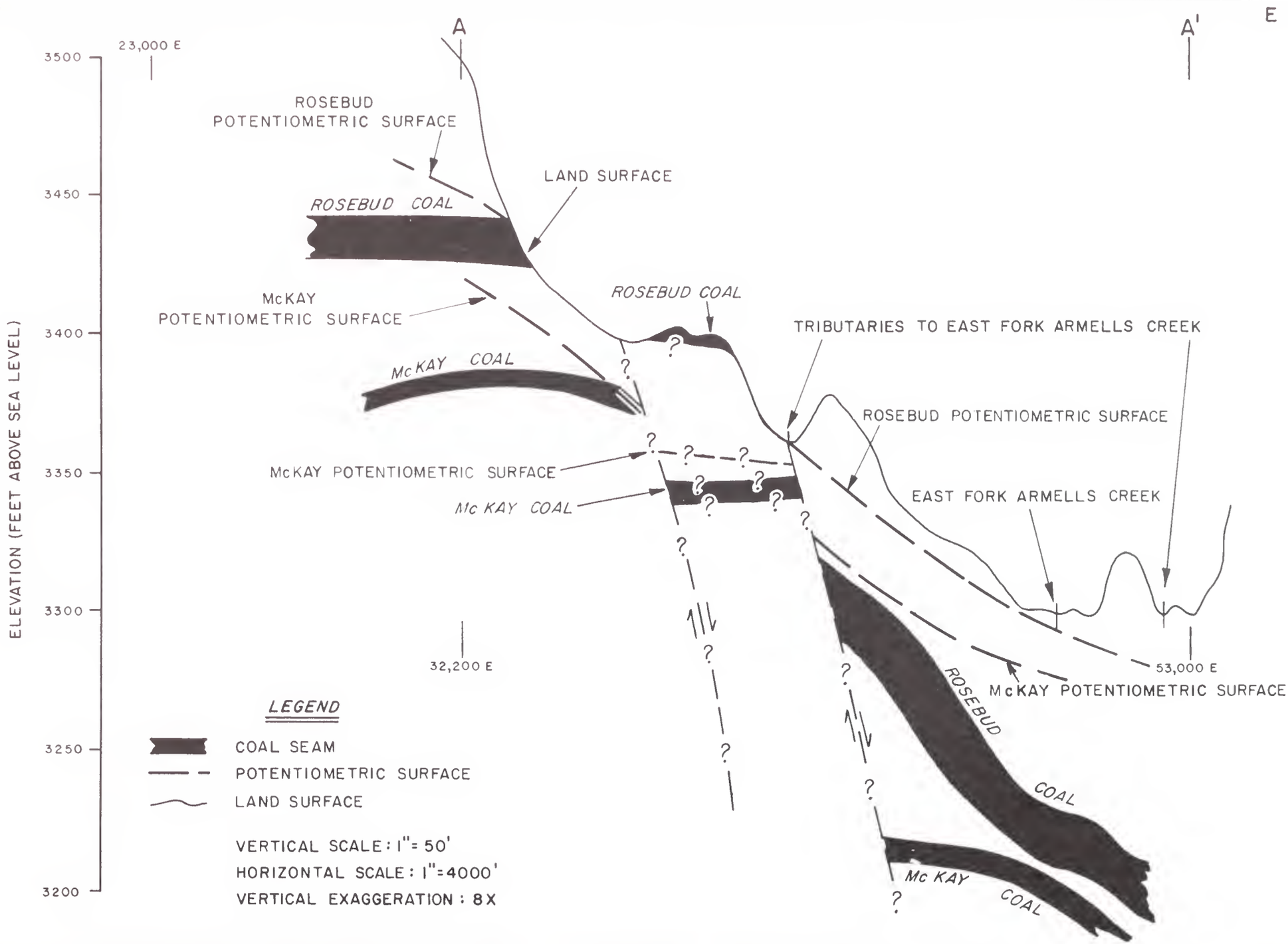


FIGURE 2.2-7 POTENTIOMETRIC SURFACE AND STRUCTURAL CROSS SECTION ACROSS TWO FAULTS ROSEBUD MINE, MONTANA

SEE FIGURE 2.2-11 FOR LOCATION OF CROSS SECTION

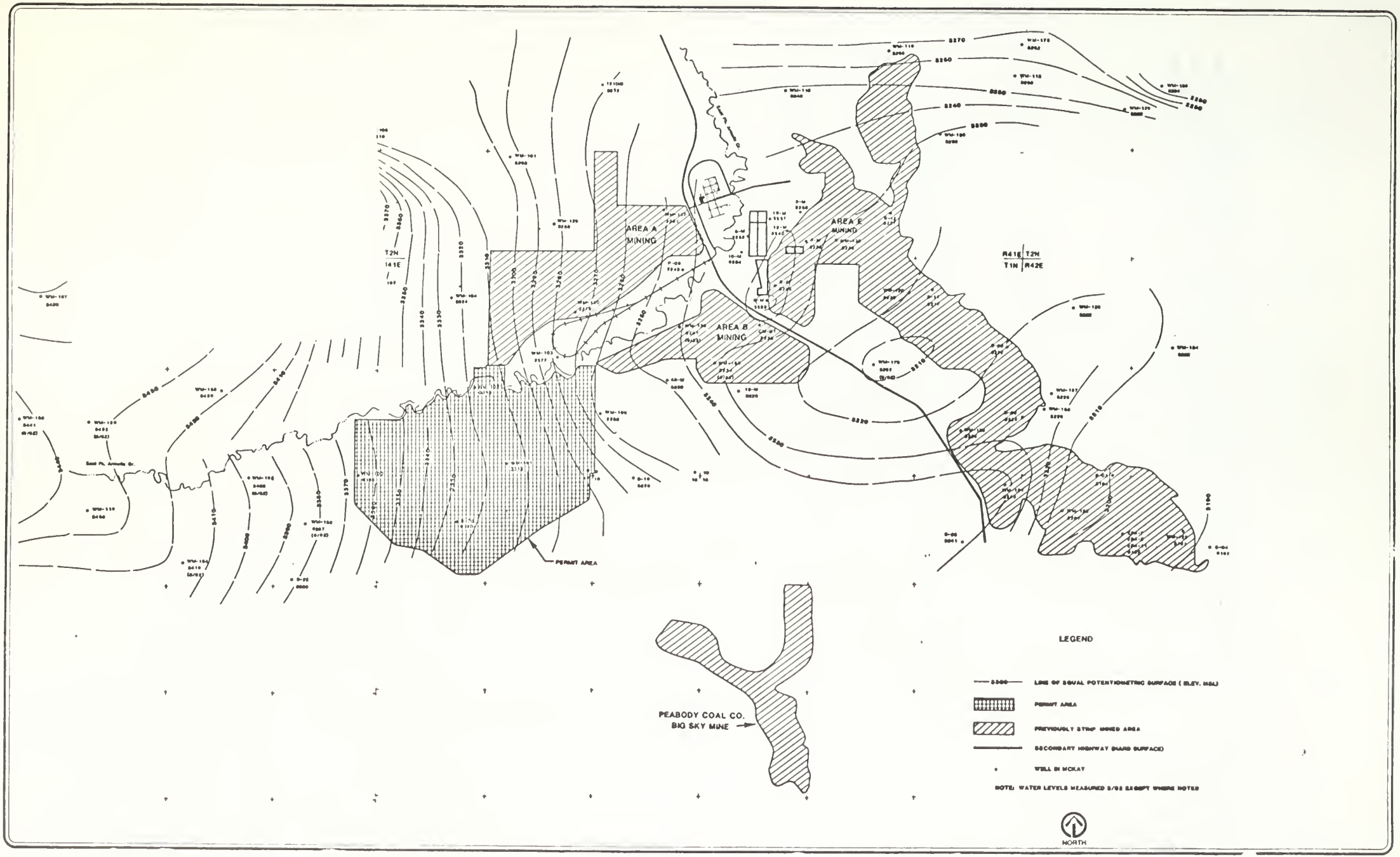


FIGURE 2.2-8 REGIONAL POTENTIOMETRIC SURFACE OF McKAY COAL AQUIFER, ROSEBUD & BIG SKY MINES, MONTANA

Sub-McKay

Although a large percentage of domestic wells are completed in the sub-McKay unit, little specific data exist to define the groundwater flow. The aquifer is confined by a 30-foot-thick layer of clay at the top of the sub-McKay unit. This clay layer seems to separate flows in the sub-McKay from the McKay coal aquifer.

2.2.1.2.2 Aquifer Communication

There are four major modes of communication between water-bearing strata:

- o Vertical leakage from the McKay coal seam
- o Movement along faults
- o Exchange between consolidated* and unconsolidated* materials
- o Exchange between two unconsolidated, water-bearing strata

Water levels in Area B wells WM-102 and WM-103 (refer to Figure 2.2-3) completed in the McKay coal have been observed to decline. This indirectly suggests that mining of the Rosebud coal in Area B has allowed an increase in upward leakage from the McKay coal seam. Generally, the vertical gradient between the McKay and the Rosebud is near zero or vertically downward.

Faulting occurs in both the McKay coal and the Rosebud coal west of Colstrip. The faults and fractures might allow intermingling of water between the McKay and the Rosebud coal seams. Since the potentiometric levels of the Rosebud seam are always higher than the McKay, the intermingling must occur from water flowing down from the Rosebud.

Clearly, wherever the spoils or valley fill material are in direct contact with bedrock strata, the potential exists for either the bedrock to discharge to unconsolidated strata, which is most common, or the spoil or valley fill to recharge the bedrock.

2.2.1.2.3 Groundwater Recharge-Discharge

Groundwater recharge and discharge is usually inferred from groundwater flow data. Where a high point exists on a potentiometric surface (or groundwater contour) map, water must flow away from that area. Further, water must be contributed to the aquifer as recharge in that area for the groundwater high point to be maintained. However, a groundwater high cannot by itself be interpreted as a significant area of groundwater recharge, since spatial and topographic configurations can cause a groundwater high even if recharge is uniform through a regional area.

Groundwater discharge may be inferred to occur where groundwater contours come to the surface and the strata transmitting the water either crops out or comes close enough to surface for discharge to occur. The relationship is, of course, not always simple, and many gray areas exist.

Rosebud spoils receive net infiltration (or recharge) from precipitation from autumn to early summer. This net infiltration is probably higher in unreclaimed than reclaimed spoils. This difference is probably due to the higher evapotranspiration values in revegetated, reclaimed spoils than in unreclaimed spoils, where natural revegetation may occur slowly. It is also due to the hummocky* topography of unreclaimed spoils, where depressions trap precipitation, allowing water to infiltrate rather than run off. Unreclaimed mine spoils along the eastern edge of Area E once may have been significant sources of recharge to the headwater area of Cow Creek and South Fork Cow Creek alluvium. Now, however, most of these unreclaimed mines spoils, left by the Northern Pacific Railroad, have been reclaimed.

Figure 2.2-9 depicts recharge and discharge areas in the valley fill material along East Fork Armells Creek. For most of its course above Colstrip, the valley fill is recharged from underlying and adjacent bedrock and from adjacent spoils. For a short section above Colstrip, however, the valley fill becomes a losing* system. Here, the fill discharges to bedrock primarily because of drawdown effects from mining in Area B. Immediately upstream and downstream from Colstrip, insufficient data exist to establish a relationship; however, it is logical to assume that the valley fill in this area continues to receive recharge from the bedrock.

The MPC power plant surge pond is located along the western flank of the valley downstream from Colstrip (Figure 2.2-10). Seepage from the surge pond via underlying strata was estimated to be about 175 acre-feet per year, or 110 gpm. Valley fill groundwater contours of East Fork Armells Creek show the influence of seepage from the surge pond on the valley fill. This influence is visible as a groundwater mound, causing flow to move perpendicular to the direction of the creek, rather than subparallel to it. It is probable that surge pond leakage contributes to bedrock recharge east of East Fork Armells Creek.

Recharge to the valley fill system occurs from seepage from various manmade sources in the Colstrip area. The combined estimated seepage from the surge pond, the fly ash pond and the power plant ponds to the valley fill system has been estimated to be 256 acre-feet per year (Hydrometrics, 1981). An additional 210 acre-feet per year of effluent discharge from the sewage treatment plant represents a potentially significant addition to the East Fork Armells Creek valley fill hydrologic system (combined surface and alluvial groundwater). Seepage from the unlined sewage lagoon adds more water to the system. Detailed monitoring of this seepage has not been performed by the town of Colstrip to quantify the seepage volume.

The addition of more than 466 acre-feet per year of water to the valley fill system can have several effects. The most immediate and apparent effect would be an increase in downgradient water table elevations and the possible increase in streamflow in the valley fill system. Flow in the valley fill system is now approximately 1,160 acre-feet per year. The 466 acre-feet per year being added represents 40 percent of the total flow in the system.

The additional flow volume can also cause an increase in groundwater discharge in other surface water drainage systems. Along this reach of the

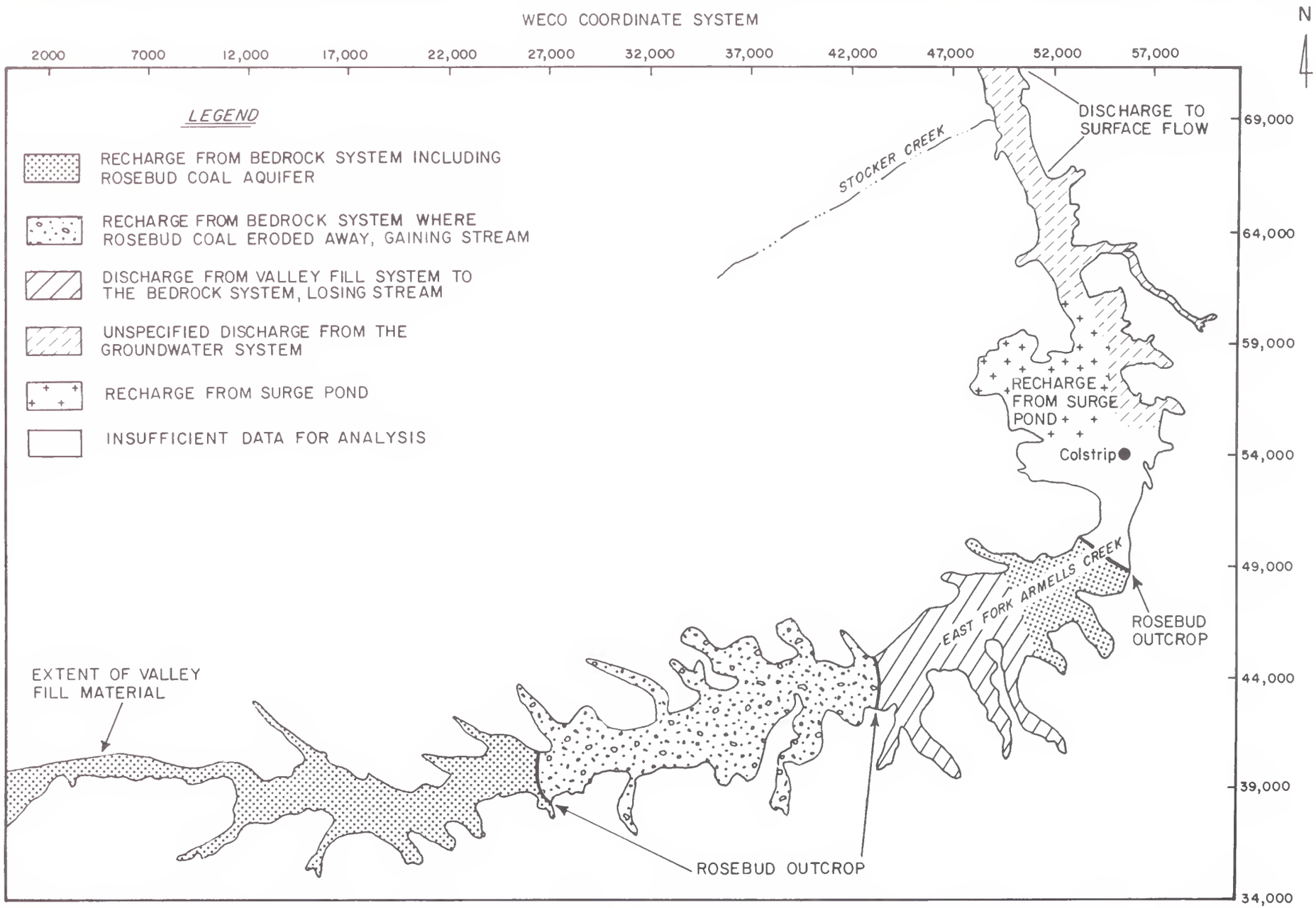


FIGURE 2.2-9 RECHARGE / DISCHARGE AREAS OF THE VALLEY FILL MATERIAL FOR EAST FORK ARMELLS CREEK, ROSEBUD MINE AREA, COLSTRIP, MONTANA

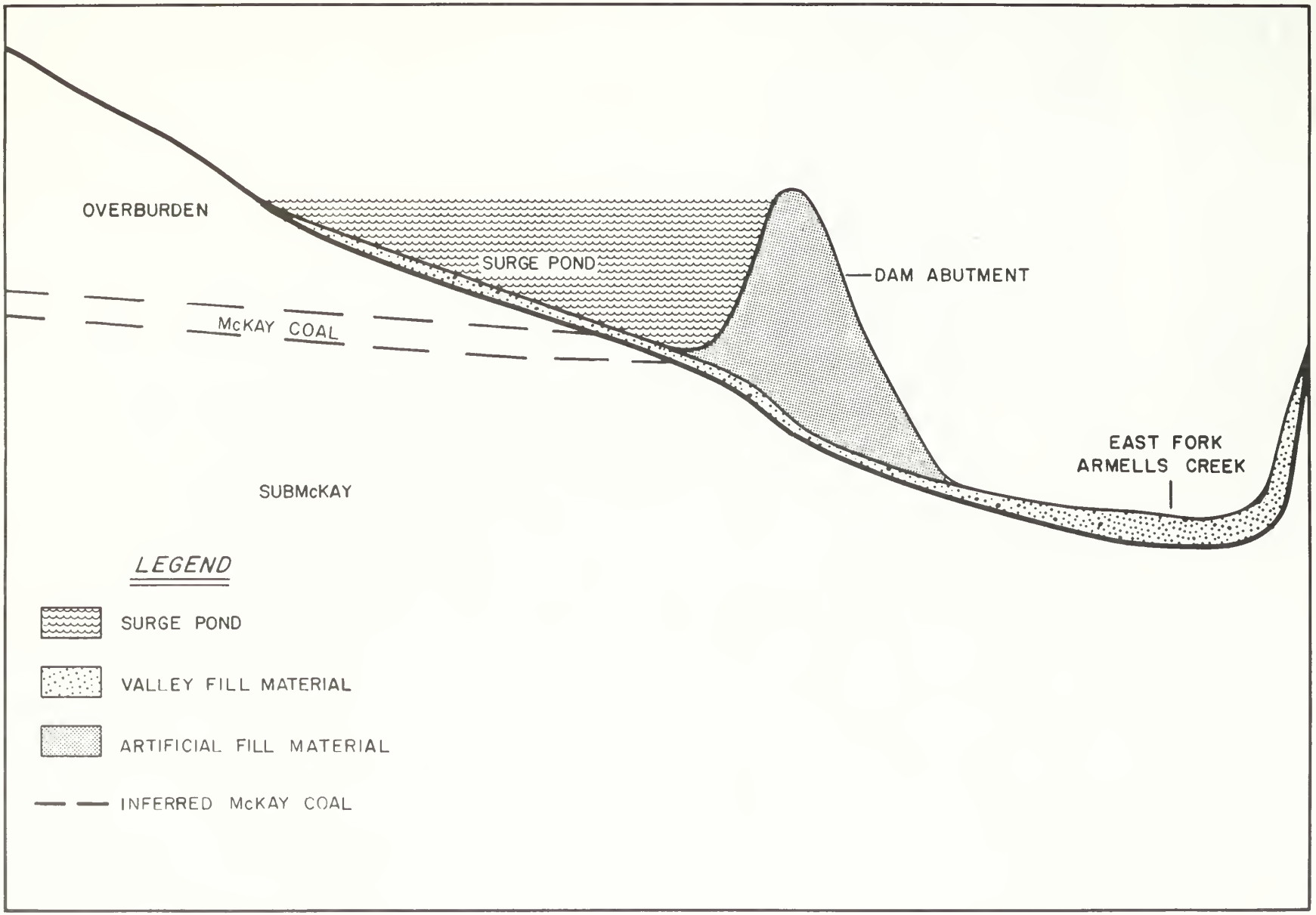


FIGURE 2.2-10 SCHEMATIC WEST-EAST CROSS SECTION ACROSS SURGE POND, COLSTRIP, MONTANA

valley fill system, the adjacent bedrock units to the east are being recharged by waters from the valley fill. This recharge will be manifested as an increase in the potential discharge to downgradient drainage systems. Those systems that are most likely to be affected are the drainages located east and southeast of Colstrip. The effect that this increase in discharge has on surface water use in these drainages cannot be quantified because background monitoring was not performed prior to the start of operations of the various ponds and the sewage treatment plant.

The amount of net infiltration to the valley fill depends on the season. During summer, valley fill groundwater is diminished by baseflow and plant uptake; during autumn, winter, and early spring, groundwater is increased by infiltration.

Recharge of near-surface, water-bearing strata occurs primarily west of the Rosebud Mine. Minor recharge occurs along certain reaches of East Fork Armells Creek and along the sandstone bluffs south of Area B and in Area A. Groundwater discharge from the Rosebud overburden and coal seam occurs along portions of East Fork Armells Creek (Figure 2.2-9) and to tributaries of Rosebud Creek south and east of Colstrip (Figure 2.2-11). The Rosebud/McKay interburden, McKay coal seam, and sub-McKay sandstones discharge to tributaries of Rosebud Creek, as shown in Figure 2.2-11.

2.2.1.2.4 Groundwater-Surface Water Relationships

Within the hydrologic study area, groundwater from the bedrock aquifers discharges to valley fill and thence to surface water along short reaches of East Fork Armells Creek above Colstrip. For a segment of East Fork Armells Creek above (and probably below) Colstrip, the stream and the valley fill recharges the bedrock aquifer. Leakage from the surge pond to valley fill aquifers and then to East Fork Armells Creek occurs below Colstrip. Pond seepage amounts are presented in Table 2.2-2.

To the southeast, a major groundwater discharge zone occurs along a series of coulees that flow into Rosebud Creek (refer to Figure 2.2-11). The Rosebud and McKay coal seams both discharge along the outcrops in these coulees, contributing to the valley fill groundwater flow.

During periods of high streamflow, surface water may recharge valley fill. Later, this water would either drain back into the channel or remain as part of the valley fill groundwater, depending on the groundwater level.

2.2.1.2.5 Subirrigation

The extent of subirrigation in the valley fill material depends on depth to groundwater, texture of the valley fill material, the type of vegetation, and the relationships between ground and surface water. Subirrigation occurs where a combination of groundwater depth and capillary fringe brings water to within 14.5 feet of the ground surface. The 14.5-foot depth is considered the maximum depth at which alfalfa can efficiently obtain water for plant maintenance and growth (Dollhopf, 1981).

TABLE 2.2-2

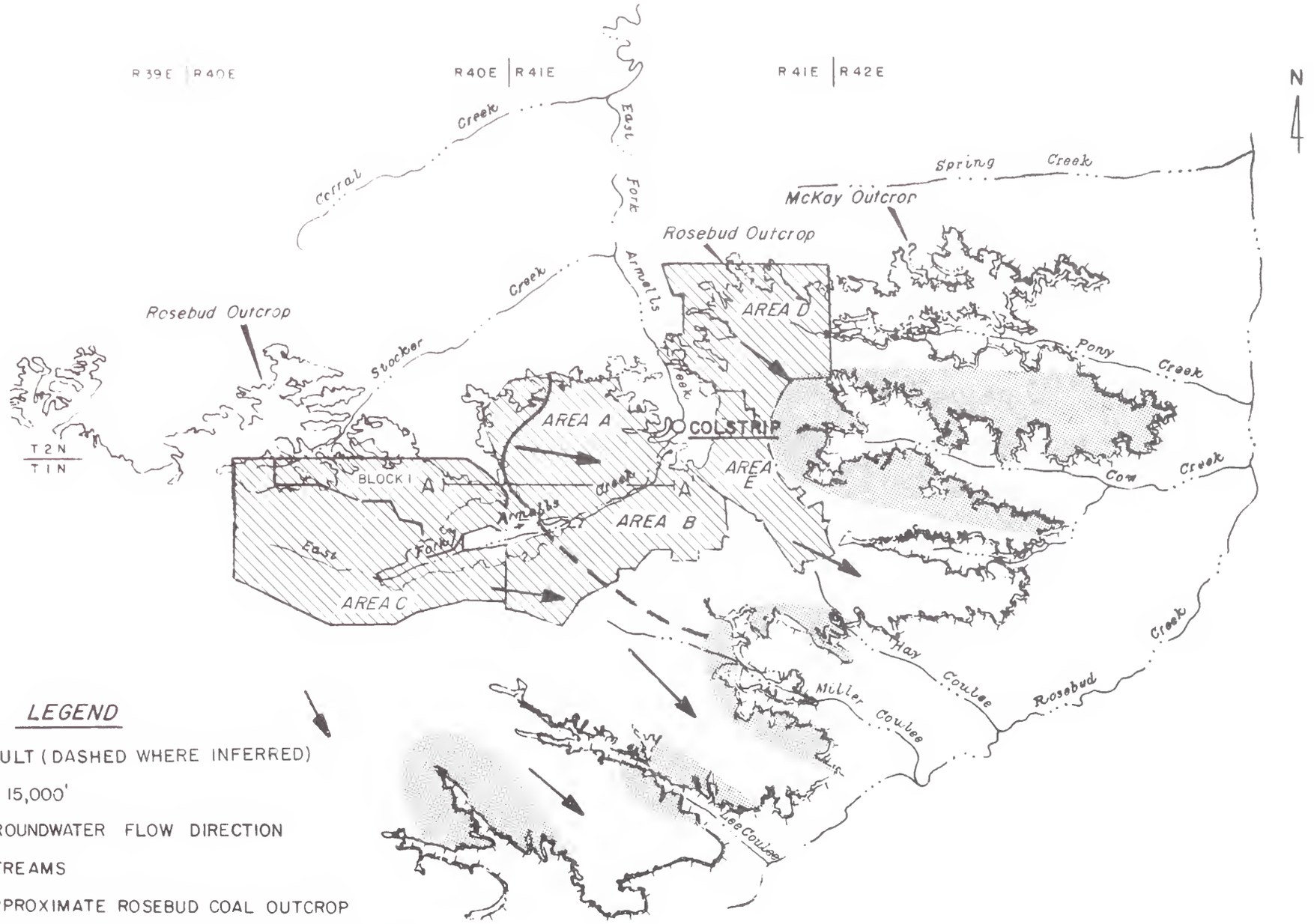
ESTIMATED POND SEEPAGE AMOUNTS

Source	Location	Estimated Seepage (acre-feet/year)	Lining
Fly Ash Evaporation Pond[1]	N1/2, Sec 29 T2N R41E	21	Partially blanketed
Surge Pond	S1/2, SW1/4, Sec 27 T2N, R41E	175	Partially blanketed
Sewage Lagoon	SW1/4, SW1/4, Sec 27 T2N, R41E	210	Unlined
Fly Ash Clearwater Pond[1]	NW1/4, NW1/4, SE1/4, Sec 34, T2N, R41E	A	3 ft. clay blanket
Wash Tray Pond[1]	NW1/4, NW1/4, SE1/4. Sec 34, T2N, R41E	A	3 ft. clay
Fly Ash Disposal[1]	W1/2,W1//2, SE1/4, Sec 34, T2N, R41E		Compacted silty clay liners
Pond A		A	
Pond B		A	
Bottom Ash Pond[1]	SW1/4, SE1/4. Sec 34 T2N, R41E	13	3 ft. clay blanket
Brine Waste Ponds[1]	SE1/4, SE1/4, Sec 34 T2N, R41E	0	Hypalon membrane
Cooling Tower Blowdown Pond[1]	NW1/4, NE1/4, Sec 3 T1N, R41E	24	Compacted silty clay liner
TOTAL		464	

[1] Hydrometrics, July 1981.

A Combined aggregate seepage estimate for all ponds - 21 acre-feet/year

Note: New data now available.



GENERAL FLOW DIRECTION AND DISCHARGE AREAS OF THE ROSEBUD COAL AND McKAY COAL, ROSEBUD MINE, MONTANA

Along East Fork Armells Creek, a capillary fringe of 2.5 feet was estimated, based on averaged textural analyses and discussions with Dr. Doug Dollhopf of Montana State University. Thus, a depth to groundwater of 17 feet is considered the maximum for subirrigation to occur along East Fork Armells Creek. Figure 2.2-12 illustrates the areas in which, according to the above criteria, subirrigation is known or expected to occur.

2.2.1.3 Groundwater Quality

Groundwater quality in the Rosebud Mine area is influenced and controlled by geology, climate, and human activities. Geologic materials controlling near-surface water quality are Rosebud spoils, valley fill material, Rosebud coal overburden, Rosebud coal, Rosebud/McKay interburden, and McKay coal. The influence of climate on water quality in the Rosebud Mine area is generally related to the number, duration, and frequency of precipitation events. (See Section 2.3.) Human activities influencing groundwater quality are mining, the MPC electric generating facility, and community activities in Colstrip. The area potentially affected by human activities is depicted in Figure 2.2-13.

2.2.1.3.1 Water Quality Suitability

Suitability of waters for irrigation depends mainly on such factors as soil type, drainage conditions, management practices, crop type, and the salinity* hazard* of the water. The classification below, modified from the U.S. Salinity Laboratory Staff (1954), is often used with respect to irrigation water:

Salinity Hazard	Range of Total Dissolved Solids (TDS)
Low	Less than 200 mg/l
Medium	200-600 mg/l
High	600-1,800 mg/l
Very High	More than 1,800 mg/l

The salinity laboratory classification applies to irrigation waters generally. As salinity levels approach "very high," even semi-salt-tolerant plant species can begin to lose vigor, reducing vegetative productivity. "High" levels of salt can decrease plant cover and germination success.

Raising livestock is an important industry in Rosebud County; thus stock watering is an important water use. Livestock tolerance to high levels of dissolved solids depends on the type and age of stock and on the period of adjustment to higher levels.

The following parameters are used by the Montana Department of Livestock, Diagnostic Laboratory, in evaluating water for livestock use (National Academy of Sciences, 1974). These parameters are presented with a margin of safety incorporated, and special circumstances may dictate the use of water otherwise considered not suitable.

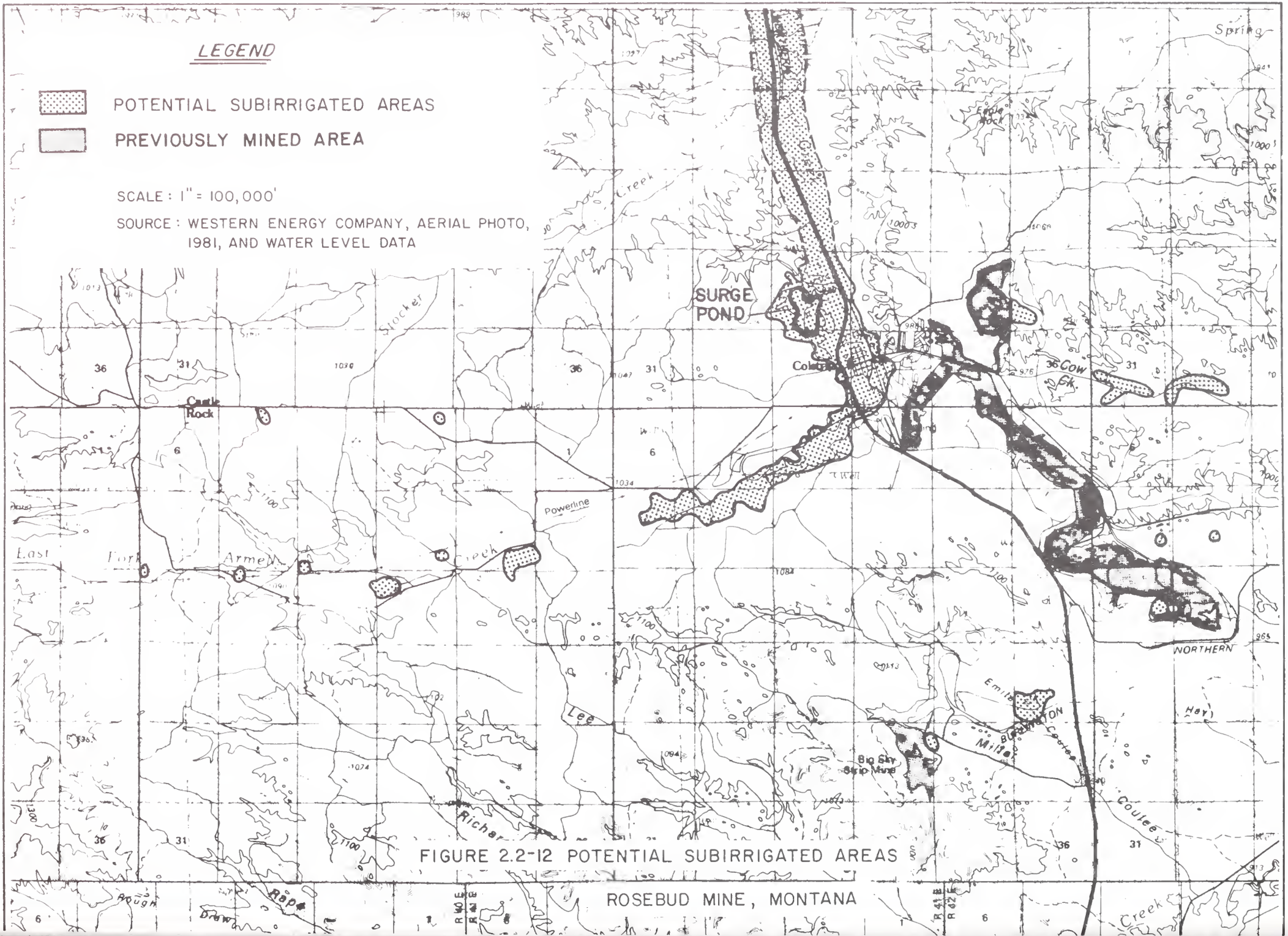


FIGURE 2.2-12 POTENTIAL SUBIRRIGATED AREAS

ROSEBUD MINE, MONTANA

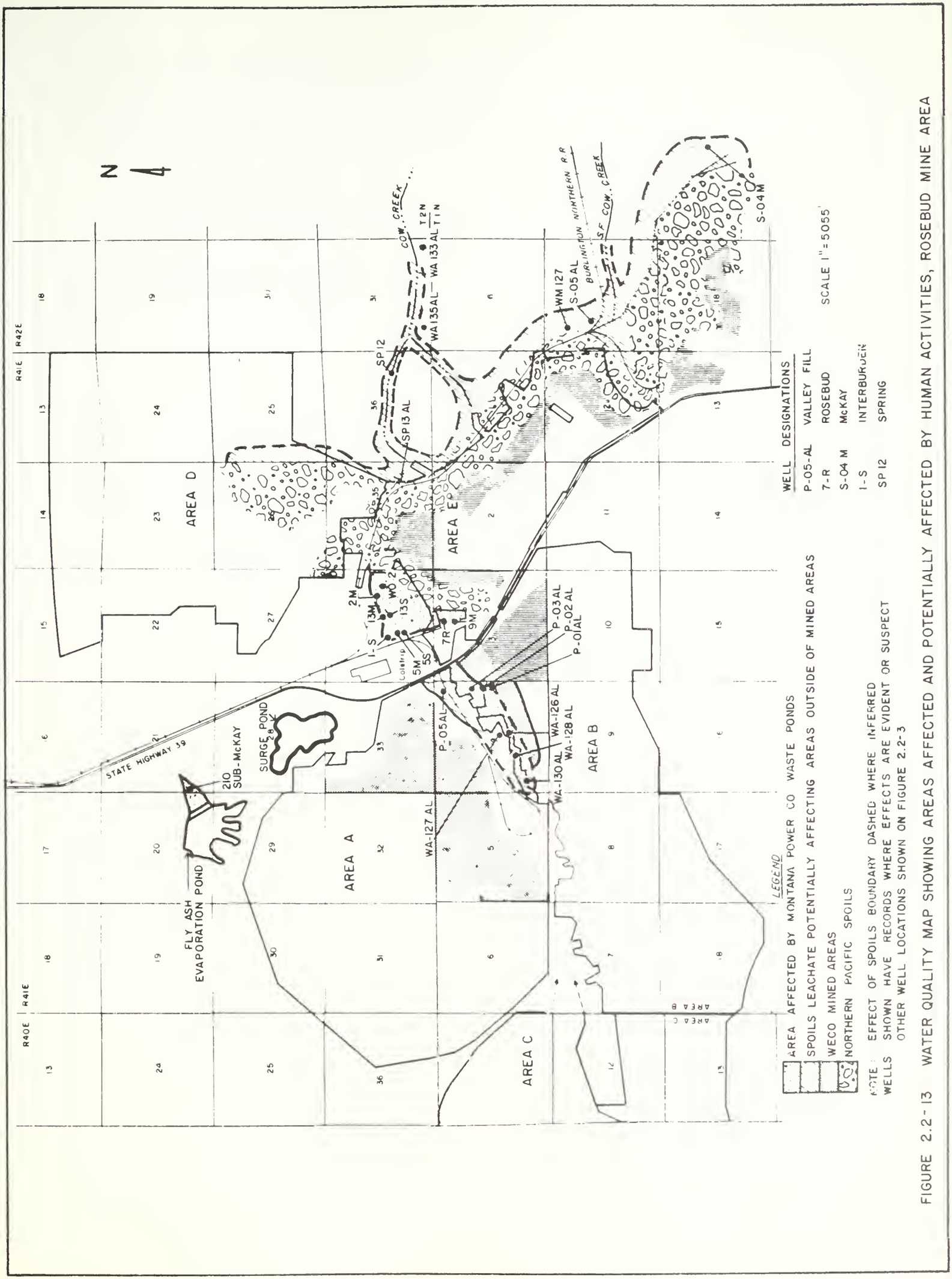


FIGURE 2.2-13 WATER QUALITY MAP SHOWING AREAS AFFECTED AND POTENTIALLY AFFECTED BY HUMAN ACTIVITIES, ROSEBUD MINE AREA

Total Dissolved Solids (TDS)	Comments
Less than 1,000 ppm*	Suitable for all classes of livestock.
1,000 to 2,999 ppm	Suitable for all classes of livestock. Poultry may experience mild, transient diarrhea.
3,000 to 4,999 ppm	Suitable for livestock use except for poultry, which may experience a decrease in performance or possible mortality.
Greater than 5,000 ppm	Not suitable for livestock use.
Other Parameters	
Mg and Na sulfates-- greater than 5,000 ppm	Not suitable for livestock use.
Alkalinities--- $CaCO_3$, OH, HCO_3--- greater than 2,000 ppm	Decrease the suitability of water at levels greater than 2,000 ppm.
Nitrates--- greater than 450 ppm	Water not suitable for livestock use.

*parts per million (ppm) is equal to milligrams per liter (mg/l).

Poultry, pigs, horses, cattle, and sheep (in that order) have increasing tolerance to salinity. McKee and Wolf (1971) list the suggested upper limits of dissolved solids concentration for various types of stock:

Livestock	Concentration, in milligrams per liter
Poultry	2,860
Pigs	4,290
Horses	6,430
Cattle (dairy)	7,150
Cattle (beef)	10,100
Sheep (adult)	12,900

As TDS levels increase two ranges less suitable for livestock, more water must be consumed to maintain body weights. Continued use of water with TDS levels above those considered suitable could result in weight loss and possible mortality. Major ions may be more limiting than total concentrations. For example, stock can tolerate higher dissolved solids when the water is a sodium-chloride type (McKee and Wolf, 1971) and considerably less if the salts are purely sodium/magnesium-sulfate type (National Academy of Sciences, 1974).

For most groundwater in the Rosebud Mine, average TDS concentrations normally range from 1,500 to 2,500 mg/l. For livestock use, this range would fit Montana stock watering standards of "fair" to "good." For irrigation purposes, the salinity hazard classification indicates that a "very high" hazard exists.

2.2.1.3.2 Aquifer Water Quality

A summary of water quality constituent concentrations for aquifers in the Rosebud Mine area is provided in Table 1 of Appendix B and is detailed in the following sections.

Rosebud Spoils

The groundwater in the spoils generally has higher TDS concentrations than the Rosebud overburden or the Rosebud coal aquifers. The average TDS level in the Rosebud Mine area for waters from 35 spoils wells is 3,300 mg/l, compared to 1,250 mg/l for 22 wells in the Rosebud overburden aquifer and 1,890 mg/l for 55 wells in the Rosebud aquifer. TDS levels of spoils waters at the Big Sky Mine average 3,400 mg/l.

Increases in calcium, magnesium, sodium, bicarbonate, sulfate, and chloride were recorded from spoils wells. These increases were generally in proportion to the TDS increases over pre-mine Rosebud overburden and coal water quality. Concentrations and ranges of individual constituents are presented in Table 1 of Appendix B. The pH* of spoils waters is slightly lower than that of overburden waters. Spoils water pH ranges from about 6.8 to 7.8, whereas overburden water pH ranges from 7.2 to 8.4. Iron concentrations are slightly lower, and manganese slightly higher, in spoils waters than in overburden waters. Other trace elements are comparable in overburden and spoils. Spoils waters fall into a fair-to-poor category for livestock watering. Spoils waters are generally suitable for most livestock uses.

Valley Fill Aquifer

Water quality in the valley fill of the Rosebud Mine area varies; TDS ranges from about 1,300 to 6,000 mg/l and averages about 2,800 mg/l. Highest concentrations, 3,500 to 6,000 mg/l, are found at random locations and result from both natural and man induced causes.

An effect of mining operations on valley fill water quality in the headwaters of Cow Creek is suspected. However, some of these apparent effects may result from natural causes. Because no detailed water quality investigation was prepared for Cow Creek prior to mining (before 1924) a comparison of pre-mining and post-mining TDS levels cannot be made. TDS increases in the East Fork Armells Creek alluvium between Areas A and B are the result of spoils water seepage. The mine spoils in Area A have partially resaturated, and spoils water flow from Area A into the alluvium has reestablished.

Wells showing evidence of high TDS concentrations are as follows:

Well Number[1]	Maximum TDS Concentration (mg/l)	Area-Location
S-05	6,000	Cow Creek
S-13	4,530	Cow Creek
WA 142	4,780	Cow Creek
WA 135	4,180	Cow Creek
PO-4	4,310	Areas A and B, E. Fork Armells Creek
PO-5	5,110	Areas A and B, E. Fork Armells Creek

[1] Refer to Figure 2.2-3 for well locations.

Water quality in the Armells Creek valley fill adjacent to Area C has not been adversely affected by mining and is more variable than that of other undisturbed areas. TDS concentrations range from 1,390 mg/l in well WA-103 to 4,680 mg/l in well WA-121 (Figure 2.2-3). Based on two samples, higher concentrations are found toward the western end of the area and in Stocker Creek headwaters, where concentrations predominantly range from 2,000 from 4,000 mg/l. In the eastern portion of Area C and in the mid-reach of Stocker Creek, concentrations range from about 1,500 to 2,000 mg/l. The water is a magnesium-sulfate type with hardness* ranging from 837 to 2,430 mg/l.

Trace element and nutrient levels are at or near detection levels, which are well below drinking water standards, and should present no problems. All valley fill waters should be suitable for stock watering, the primary use in this area.

Rosebud Coal Overburden

Most information on water quality in the Rosebud coal overburden was collected by Dollhopf et al. (1978, 1979) during studies in Area B. TDS concentrations in Area B range from 600 to 2,500 mg/l and average 1,850 mg/l. At the writing of this EIS, there was one overburden well in Area D (WO-104) for which data was available. The TDS concentration measured once at that well was 644 mg/l.

Analyses of water from three wells, WO-101, WO-103, and PW-03 (Figure 2.2-3), drilled in the overburden in Area C show that TDS levels range from 400 to 2,300 mg/l. Although the information collected was insufficient for statistical comparison, the data are similar to data for Area B.

Rosebud Coal

Some of the best quality groundwater in the Rosebud Mine area is found in the Rosebud coal aquifer (Table 1, Appendix B). Although TDS concen-

trations range from 400 to 6,500 mg/l, most water-sample TDS concentrations range from 400 to 1,500 mg/l. Only three wells have average TDS concentrations greater than 3,000 mg/l in the Rosebud Mine area, two of which are located in the headwater area of East Fork Armells Creek and Stocker Creek in Area C (wells WR-103 and WR-121 in Figure 2.2-3). The western part of Area C is used for dryland farming.

The three wells drilled in Area C have the following TDS concentrations: WR-122, 534 mg/l; WR-117, 459 mg/l; and WR-126, 2,260 mg/l (Figure 2.2-3). Well WR-126 is located along the outcrop of the Rosebud coal, where mineralization from the overlying shale and surface weathering are considered responsible for the higher concentration. Much of the water underlying Area C is probably similar in quality to that of wells WR-117, WR-122, and WR-126.

Data from 19 wells were used for calculating the average TDS concentration for Area B. Most of the wells had a long history of use for monitoring purposes. The average TDS concentration is 1346 mg/l, ranging from 434 mg/l to 2,988 mg/l. The majority of the wells have TDS concentrations of 1,200 mg/l and above.

For this analysis three wells in each of Areas A, D, and E were used for the calculation of average chemical concentrations. The results are listed in Tables B-1 and B-2 (Appendix B). Area E seems to have the highest TDS concentrations.

Interburden Aquifer

TDS concentrations for all interburden wells in the Rosebud Mine area range from 260 to 3,500 mg/l; the TDS levels mainly fall in the range of 1,500 to 3,000 mg/l. There are no wells in the Rosebud Mine area to indicate that waters from spoils have contaminated or penetrated the interburden aquifer; however, power plant wastes appear to have caused an increase in TDS in the interburden aquifer near the townsite of Colstrip and at fly ash pond 210, located about 2 miles northwest of Colstrip (see following discussion on McKay coal). In 1980, water in some wells located below or near industrial ponds had TDS concentrations as high as 8,000 to 9,000 mg/l. Pre-mining levels were probably in the range of 500 to 3,500 mg/l (Botz, 1978). The water can be characterized as calcium-sulfate or magnesium-sulfate water.

McKay Coal

TDS concentrations in the McKay coal normally range from about 500 to 2,500 mg/l, except for Area E, where wells S-04 (5,725 mg/l TDS), S-08 (3,192 mg/l TDS), and WM-127 (7,455 mg/l TDS) (Figure 2. 2-3) indicate elevated average TDS values (see Table 4 of Appendix B). The data for well S-04 also appear to indicate a cyclic increase in TDS, indicating an external source of the salinity. This cyclic effect on TDS can be noted in data from other wells with sufficiently long periods of record. The noted increases and fluctuations may also be due to an external source of con-

tamination of the well and, therefore, cannot be conclusively tied to seepage of mine spoil waters.

Two types of water are found in the McKay aquifer: magnesium-sulfate and sodium-sulfate. Magnesium-sulfate water is found in most of Areas B and E, in the eastern and western portion of Area C, and in parts of Area D. Sodium sulfate waters are present in the central portion of Area C, in the northern portion of Area A, in Area D, and in one well at the Big Sky Mine.

Sub-McKay Aquifer

TDS concentrations in the sub-McKay waters of the Rosebud Mine area range from 840 to 3,320 mg/l. The average of 19 sub-McKay wells was 1,700 mg/l. The majority of waters in the sub-McKay aquifer in the Rosebud Mine area are of the sodium-sulfate type. Water quality data are available for two wells in Area C, WD-101 and WD-102 (Figure 2.2-3). Well WD-101 has water of a sodium-sulfate type and WD-102 yields magnesium-sulfate type water.

2.2.1.4 Groundwater Use

Groundwater use in the Colstrip area is devoted mainly to stock-watering. Below on the left is a breakdown by type of the groundwater uses in the Colstrip area. On the right is a breakdown by source.

Type	Percent
Stock	81
House	8
Public	3
Irrigation	2
Fire	0.5
Industrial	0.5
Unused	5
Total	100%

Source	Percent
Sub-McKay sandstone	46
Rosebud overburden	13
Rosebud coal	8
Alluvium	7
McKay coal	3
Tullock Formation	2
Hell Creek Formation	1
Rosebud clinker	0.5
Madison Formation	0.5
Unknown	19
Total	100%

Water for the Colstrip townsite and power plants is piped from the Yellowstone River, although the community has three backup wells completed in the sub-McKay. Water for mine operations, such as haul road watering, is obtained from pit inflow and surface runoff.

Ephemeral* springs are also used for livestock watering. Table B1-3 in the Technical Support Document (available at the Department of State Lands, Helena) lists the springs located in the hydrologic study area; Plate B-2 shows the spring locations. Specific information on private wells and groundwater rights can also be found in the Technical Support Document (Tables B1-1 and B1-2, and Plate B-2).

2.2.2 Surface Water

The surface hydrologic study area has been divided into two separate units: (1) the East Fork Armells Creek drainage, including Upper East Fork Armells Creek and Stocker Creek, which drains mine Areas A, B, and C and portions of Areas D and E; (2) Spring, Cow, and Pony Creeks, which are tributaries of Rosebud Creek and drain the eastern portions of mine Areas D and E (Figure 2.2-14).

Stocker Creek, with a drainage area of 26.1 square miles flows into East Fork Armells Creek about 3 miles north of Colstrip. At the confluence of these two streams, the total drainage area is approximately 73.8 square miles. A total of 3,532 acres (5.5 square miles) of the mine area is within the Stocker Creek drainage, and 12,200 acres (19.1 square miles) is within the East Fork Armells Creek drainage (Figure 2.2-14). The Pony Creek drainage occupies approximately 14.2 square miles, of which 450 acres will be in the permit area and 430 acres will be disturbed by mining. The Cow Creek drainage is approximately 26.5 square miles. Cow Creek drains eastward into Rosebud Creek, of which approximately 160 acres will be disturbed by mining. Spring Creek drains the northern portion of mine Area D of which approximately 765 acres may be disturbed by mining.

The Cow Creek and Pony Creek drainages were analyzed separately from the East Fork Armells Creek drainage because Area E has internal drainage which preempts the use of standard surface hydrologic flow prediction methods. Models cannot be accurately used when randomly placed, undrained, unreclaimed, topographic surfaces are encountered. Further, the Northern Pacific and Pit 6 spoils will not be reclaimed by Western Energy to the approximate pre-mine surfaces; therefore, surface hydrologic floodflow simulation techniques for pre- and post-mine conditions were not performed. Storm runoff from these areas will be extremely low or nonexistent.

2.2.2.1 Drainage Network Characteristics

East Fork Armells and Rosebud Creek tributaries reflect the influence of bedrock and structural control. This influence is strongest in the headwaters of these creeks and decreases downstream. The extent of valley fill in these drainages generally increases downstream, so that the main streams of East Fork Armells Creek and Rosebud tributaries flow within shallow

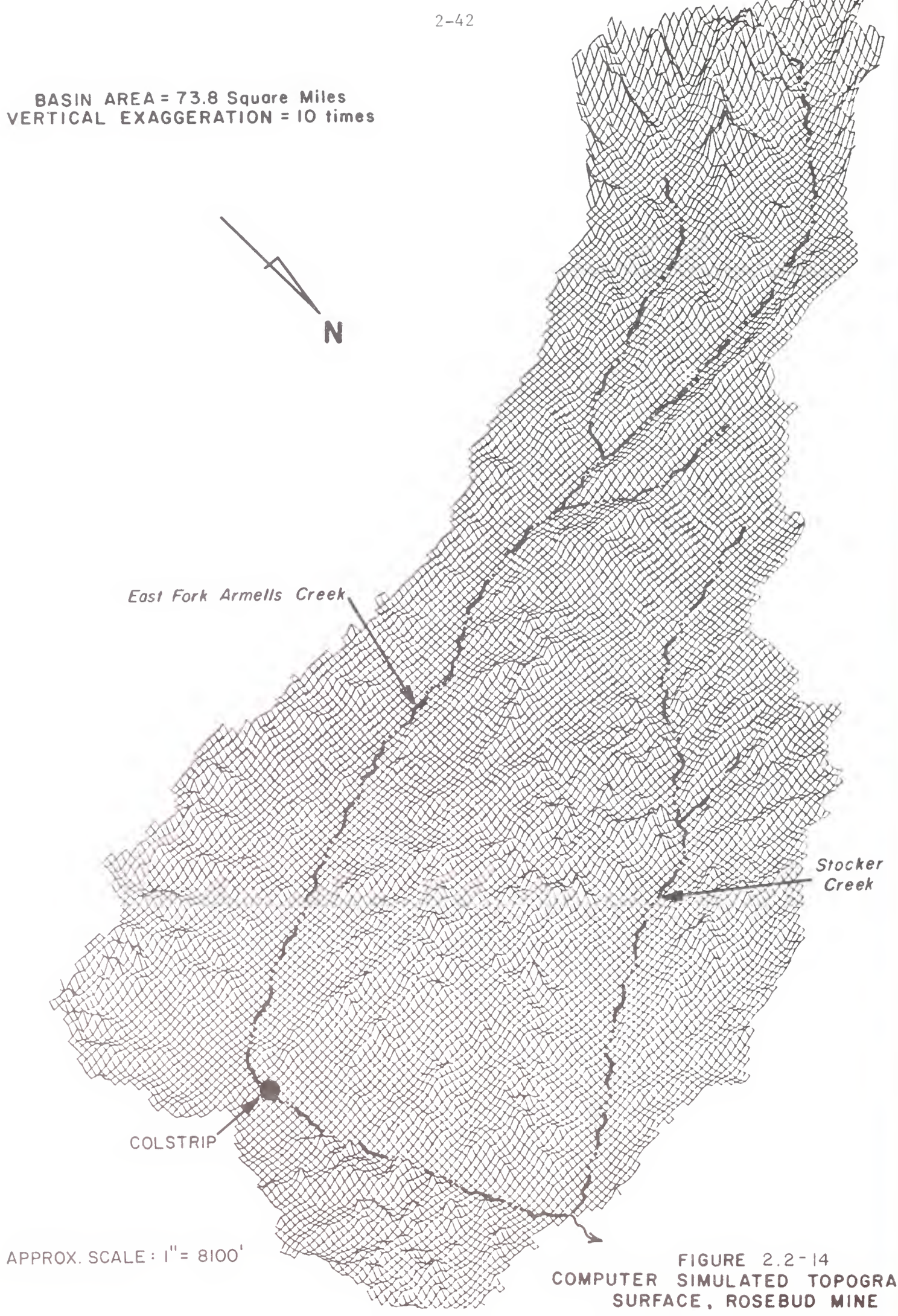


FIGURE 2.2-14
COMPUTER SIMULATED TOPOGRAPHIC SURFACE, ROSEBUD MINE

alluvial channels. The small, ephemeral* tributaries are developed primarily on bedrock throughout the study area.

Analysis of the drainage networks suggests that they are in equilibrium, where a relative balance between stream energy and transport exists. Both the main channels and tributaries within the study area are entrenched and vegetated and appear stable. Major entrenchment of the main streams of the basins is related to climatic change and base level* lowering since the Pleistocene Epoch. The stream network characteristics indicate that the tributary channels have generally adjusted to such long-term changes.

2.2.2.2 Stream Channel Characteristics

Through Area C, the main stem of East Fork Armells Creek is an alluvial channel, with sinuosities* ranging from 1.56 to 2.37. Stream sinuosities increase progressively downstream. Values of 1.6 to 2.6 have been calculated below Area B and values from 2.0 to 3.75 have been calculated at the confluence of East Fork Armells Creek and Stocker Creek. The stream sinuosities for Pony and Cow Creek within the permit area range from 1.16 to 1.25. As stream sinuosity increases, stream erosion potential decreases Similarly as sinuosities increase relative stream stability increases. The longitudinal profiles of the creek channels in the study area are generally concave and show no clear evidence of current instability, either as major slope changes or as knickpoints.* In contrast, the ephemeral channels developed on the slopes of the upland areas of Areas A, B, C, and D have straighter longitudinal profiles. Surveys of 12 ephemeral channels indicate that channel oversteepening due to deposition, followed by channel entrenchment, is common in these channels. Deposition and incision are also occurring in response to a change in base level from dam construction.

2.2.2.3 Drainage Basin Sediment Yields* and Landscape Stability

Calculations (see Section B.4 of the Technical Support Document) indicate that the sediment yields within the study are a relatively low, ranging from 0.10 to 0.43 acre-foot per square mile per year. These sediment yields are significantly below average basin yields, 0.3 to 1.0 acre-foot per square mile per year that have been measured under similar geologic conditions in the High Plains region (e.g. Schumm and Lichty, 1965; Ringen et al., 1970). This reflects the predominance of landscape units (sediment source areas) with low or moderate sediment yields and the inefficiency of the vegetated ephemeral stream channels in transporting sediment.

The results of the geomorphic studies summarized above indicate that over relatively large areas, such as the East Fork Armells Creek and Rosebud Creek tributary basins, and over a long timeframe of several hundred years, the landforms and drainage networks within the study area appear to be stable under existing environmental conditions. There is no evidence of widespread accelerated erosion. The major stream channels, although commonly entrenched, are vegetated and do not appear to be undergoing active gullying. However, on the scale of the small ephemeral

drainage outside the disturbed area but within Mine Areas A, B, C and D and Peabody Coal Company Big Sky Area A, there is some evidence (Technical Support Document, Section B.4) that natural drainage channels are inherently unstable. The instability is manifested by increased gullying during flow events, bank caving, headward erosion and creation of knick-points. Knickpoints cause convex channels which can present reclamation difficulties. Current reclamation practices will generally result in more stable drainages.

2.2.2.4 Surface Water Flows

East Fork Armells Creek and Rosebud Creek tributaries within the study area are intermittent* streams that flow in response to local and regional groundwater inflow over short reaches, as well as for short time periods in response to snowmelt and high-intensity precipitation events. The area is drained by 14 ephemeral drainages that are tributaries to East Fork Armells Creek and Stocker Creek. Eight ephemeral drainages flow from Area D and E. Four of the drainages flow from area E are part of Rosebud Creek drainage. These tributaries also flow in response to late winter and early spring snowmelt and to late spring and early summer high-intensity precipitation events. Low flow in all of the drainages in the study area is zero. Although surface water gauging stations exist in the area (Appendix B, Table 5), flow records for Rosebud Creek tributaries and East Fork Armells Creek are insufficient to accurately describe the magnitude and frequency of floods. However, techniques described by Parrett and Omang (1981) can be applied for estimating flood flows for the 2-, 5-, 10-, 25-, 50-, and 100-year floods. Estimates of flood peaks for Stocker Creek are shown in Table 2.2-3, for East Fork Armells Creek in Table 2.2-4, for Pony Creek in Table 2.2-5, and for Cow Creek in Table 2.2-6.

USGS continuous flow records for a nearby area were investigated for flow duration statistics. A relationship of the probability flow occurrence per square mile of drainage area (Appendix B, Figure 1) was computed using these flow duration statistics. The computations demonstrated a close relationship between each stream, indicating a similarity of flow characteristics in the basins (Table 2.2-7). This relationship was used to estimate flow statistics and to synthesize a probability of flow occurrence curve for East Fork Armells Creek below the confluence with Stocker Creek. The synthesized curve (Figure 2.2-15) indicates that for 90 percent of the days, flow would be less than 2.5 cubic feet per second (cfs); for 80 percent of the days, flow would be less than 1.0 cfs; and for 40 percent of the days, flow would be less than 0.01 cfs (essentially no flow). This curve illustrates that East Fork Armells Creek below the confluence with Stocker Creek has little or no natural base flow.*

The synthesized curve for Pony and Cow Creek is shown in Figure 2.2-15. The Pony Creek annual flow duration curve indicates that, for 90 percent of the days, flows would be less than 0.8 cfs. Similarly, the Cow Creek annual flow duration curve indicates that 90 percent of the days would have flows less than 1.4 cfs.

TABLE 2.2-3

FLOOD MAGNITUDE CALCULATIONS
FOR STOCKER CREEK AT MOUTH

Drainage Area (sq. miles): 26.11

Area Code: 4: Southeast Plains Region

Percent Forest Cover: 10.8

Geographic Factor: 0.8

Recurrence Interval	Flood Magnitude[1] (Cubic Feet per Second)
2	101
5	266
10	415
25	667
50	933
100	1,240

[1]Parrett and Omang, 1981

TABLE 2.2-4

FLOOD MAGNITUDE CALCULATIONS
FOR EAST FORK ARMELLS CREEK
AT CONFLUENCE WITH STOCKER CREEK

Drainage Area (sq. miles): 47.7

Area Code: 4: Southeast Plains Region

Percent Forest Cover: 10.7

Geographic Factor: 0.8

Recurrence Interval	Flood Magnitude[1] (Cubic Feet per Second)
2	145
5	379
10	584
25	928
50	1,300
100	1,720

[1]Parrett and Omang, 1981

TABLE 2.2-5

FLOOD MAGNITUDE CALCULATIONS
FOR PONY CREEK

Drainage Area (sq. miles): 14.2

Area Code: 4· Southeast Plains Region

Percent Forest Cover: 28.2

Geographic Factor: 0.8

Recurrence Interval	Flood Magnitude[1] (Cubic Feet per Second)
2	39
5	102
10	150
25	286
50	410
100	567

[1]Parrett and Omang

TABLE 2.2-6

FLOOD MAGNITUDE CALCULATIONS
FOR COW CREEK
(Excluding Area E Disturbed Area)

Drainage Area (sq. miles): 26.5

Area Code: 4: Southeast Plains Region

Percent Forest Cover: 48.4

Geographic Factor: 0.8

Recurrence Interval	Flood Magnitude[1] (Cubic Feet per Second)
2	37
5	96
10	163
25	280
50	407
100	572

[1]Parrett and Omang, 1981

TABLE 2.2-7

FLOW STATISTICS FOR SELECTED STREAMS
ROSEBUD MINE AREA

USGS Gage Number	Stream	Period of Record (Water Year)	Flow (cfs) Mean	Median	Mode	Range
062941940	Sarpy Creek near Hysham ($453\ mi^2$)	1974 through 1980 (7 years)	8.3	1.3	5.0	0-390
06294690	Tullock Creek near Bighorn ($446\ mi^2$)	1975 through 1980 (6 years)	12.3	1.1	5.0	0-1110
06294995	Armells Creek near Forsyth ($370\ mi^2$)	1975 through 1980 (6 years)	8.1	0.46	5.0	0-750
---[1]	East Fork Armells Creek ($73.8\ mi^2$)	---	1.5	0.13	---	---

[1]These flows were derived from the other recorded flows in this table.

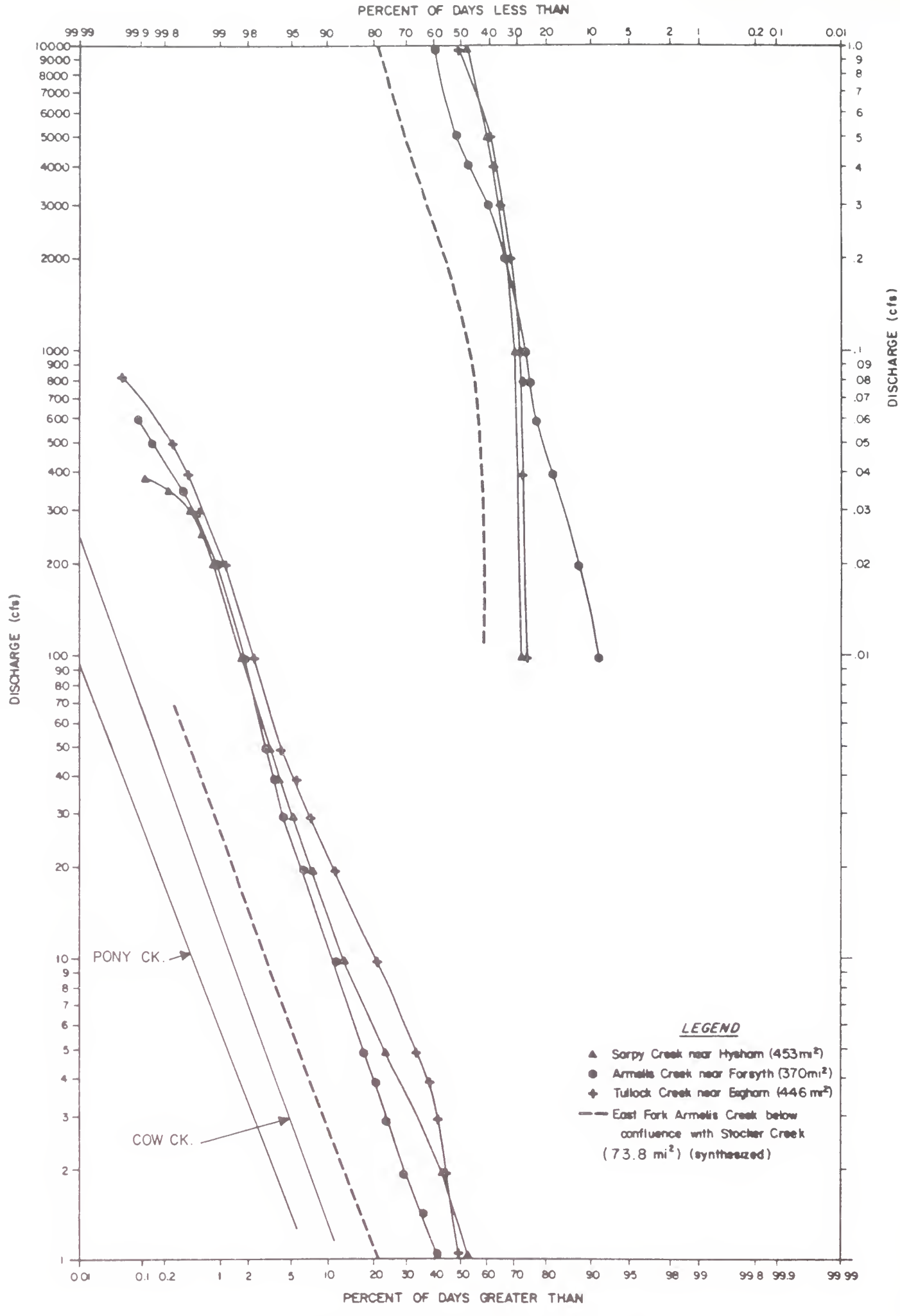


FIGURE 2.2-15 PROBABILITY OF FLOW OCCURRENCE IN DAYS

2.2.2.5 Surface Water Quality

2.2.2.5.1 Streams

East Fork Armells Creek and the headwater areas of Area D and E Rosebud Creek tributaries are ephemeral and dry for much of the year, flowing only in response to snowmelt and storm runoff (Section 2.2.2.4). Data from surrounding areas on East Fork Armells Creek and Stocker Creek have been collected by the Western Energy Company for a sufficient period of time and range of conditions to permit an adequate assessment of surface water quality. An assessment of Cow and Pony Creeks is preliminary until an adequate long-term water quality data base has been obtained. All collected data are used to supplement longer term data collected by the USGS on several streams in the area. Periods of record of complete chemical data collected almost monthly by the USGS are as follows:

Location	Period of Record
East Fork Armells Creek near Colstrip	January 1975 to May 1981
East Fork Armells Creek near Forsyth	October 1974 to October 1981
West Fork Armells Creek near Forsyth	November 1974 to June 1977
Rosebud Creek Near Colstrip	October 1974 to October 1981
Rosebud Creek above Pony Creek near Colstrip	October 1974 to November 1977
Cow Creek near Colstrip	October 1979 to May 1981

Concentrations of dissolved constituents vary greatly over time in the East Fork Armells Creek and Stocker Creek basins. The variations stem from surface runoff events that dissolve minerals from the land surface and discharge of subsurface water from valley fill, overburden, and possibly the Rosebud coal aquifer. TDS concentrations range from about 200 mg/l at highest flows to about 6,500 mg/l at low base flow. TDS concentrations generally are in the range of 3,000 to 4,500 mg/l, since low flows prevail. Table 6, Appendix B, lists TDS for samples collected by USGS for the above-listed sites in the Colstrip area. Stream discharge of the East Fork Armells Creek at Colstrip is also provided to show the relationship between conditions in the area at the time of sampling. Highest TDS concentrations (4,500 to 5,000 mg/l) frequently occur during extreme low flow, when evaporation, transpiration, and biological activity concentrate salts in water passing slowly through pools along several reaches of the stream. The TDS concentrations are usually double those found in groundwaters of the valley fill and Rosebud aquifers along stream channels. Valley fill is the predominant source of recharge to streams at low flow, supplemented by water from the Rosebud aquifer in some areas (Section 2.2.1.3).

Several areas in the East Fork Armells Creek drainage basin appear to have slightly higher TDS concentrations than those found in other stream segments in the Rosebud Mine area. This is presumed to be due to geologic differences. The areas with higher TDS are located approximately as follows: (a) the western half of Area C, (b) the upper half of Stocker Creek basin (refer to Figure 2.2-1), and (c) the upper reaches of Cow Creek near Colstrip. The evidence for these higher concentrations comes from

data collected at surface water site SW-09 in the headwaters of East Fork Armells Creek, about 1 mile southwest of Area C, Block I; and from site SW-65 on Stocker Creek, about 1 mile northwest of Area C, Block I. Data for West Fork Armells Creek (SW-09 and SW-65, see Figure 2.2-3) are provided in Table 7 of Appendix B. The soils in these areas contain higher proportions of clays and shales, which contain more soluble minerals than the sandy materials found in the remaining area (see discussions on Geology and Soils, Sections 2.1 and 2.6). The surface waters of upper East Fork Armells Creek and Stocker Creek are very hard and have a very high salinity hazard most of the time, with TDS concentrations usually above 2,500 mg/l.

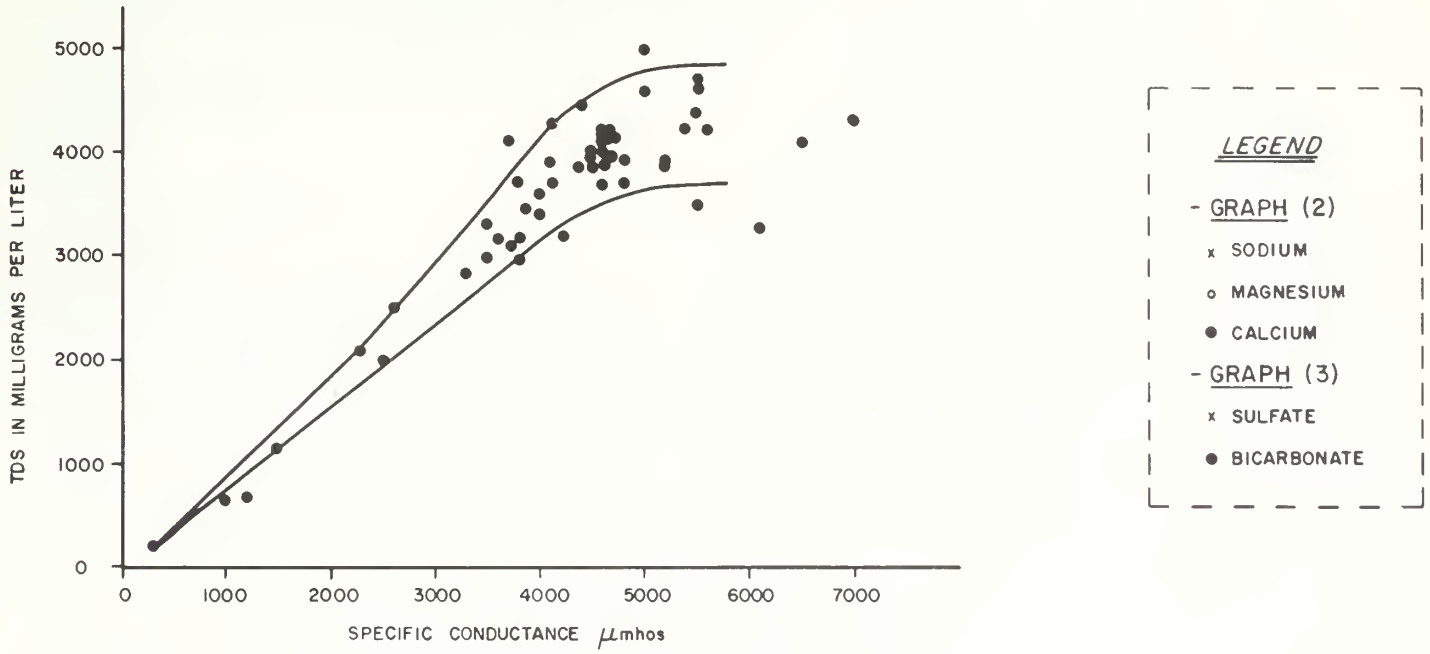
Water quality data have been collected by the U.S. Geological Survey at a station located approximately 1,000 feet downstream from the confluence of South Fork Cow Creek and Cow Creek. The mean TDS concentration at this station from October 1979 to April 1981 was 4,673 mg/l. The flow in the creek was low during fall sampling, with a mean flow of 0.23 cfs. The quality of the surface water in Cow Creek can be better quantified after a longer period of record is obtained for a variety of flows. Table 6-B, Appendix B, summarizes the U.S. Geological Survey records.

The surface waters in the Rosebud Mine area are a magnesium-sulfate type. The relationships between TDS and specific conductance and between specific conductance and calcium, magnesium, sodium, bicarbonate and sulfate are shown in Figure 2.2-16 for East Fork Armells Creek near Colstrip and in Figure 2.2-17 for Rosebud Creek.

The quality of water in the reach of East Fork Armells Creek upstream from Colstrip is similar to that shown in Figure 2.2-16(1). Concentrations occurred at the high end of the range about 80 percent of the time. Sodium, magnesium, and sulfate constituents have a linear relationship with TDS at all levels, whereas calcium and bicarbonate at these high levels reach a plateau, indicating saturation. The water is alkaline: pH 7.5 to 8.3. Nitrogen and phosphorus are usually low: nitrogen concentrations are a few tenths and phosphorus concentrations a few hundredths of a milligram per liter. The fluoride concentration is generally 0.1 to 0.2 mg/l.

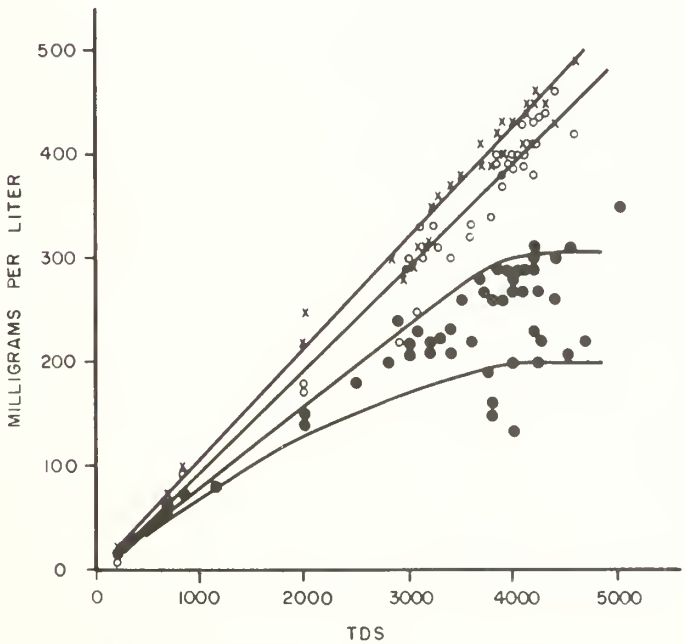
Trace metal concentrations are at or near the detection level of analytical methodology and constitute no problem, except for mercury concentrations found at several sampling points. For example, samples collected at SW-09, located about 1 mile southwest of Area C, Block I, had mercury concentrations of 0.030 and 0.040 mg/l on several occasions. These values exceed the primary drinking water standard and are believed to be anomolous, probably resulting from sampling or laboratory error.

Water quality data in Cow and Rosebud Creeks reported by the USGS from 1974 to 1980 indicate that Rosebud Creek water quality is better than any other stream draining the project area. Water quality samples indicate that TDS, sodium, magnesium, calcium, and sulfate are higher in Cow Creek. The relatively high TDS levels in the headwaters of Cow Creek are probably related to seepage of spoils water from Northern Pacific mine spoils. As long-term data become available, sources and changes in water quality characteristics can be quantified.



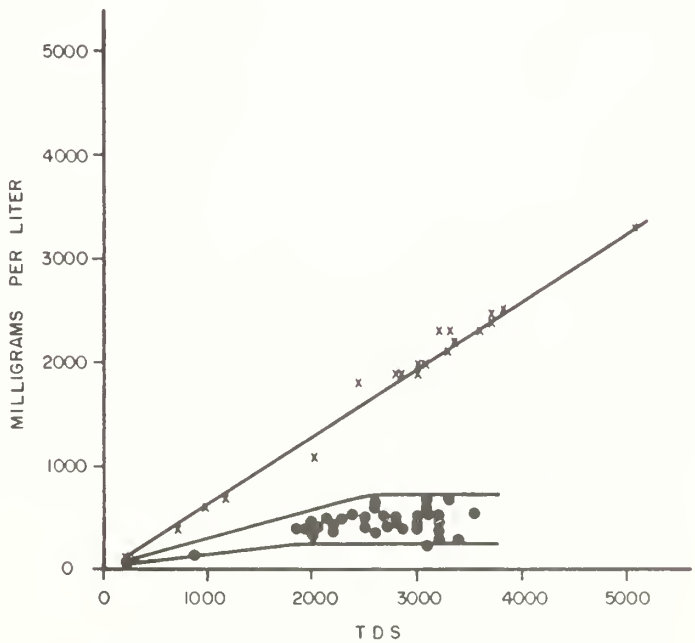
RELATIONSHIP OF SPECIFIC CONDUCTANCE TO TOTAL DISSOLVED SOLIDS FOR EAST FORK ARMELLS CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

(1)



RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS AND SODIUM, MAGNESIUM, AND CALCIUM FOR EAST FORK ARMELLS CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

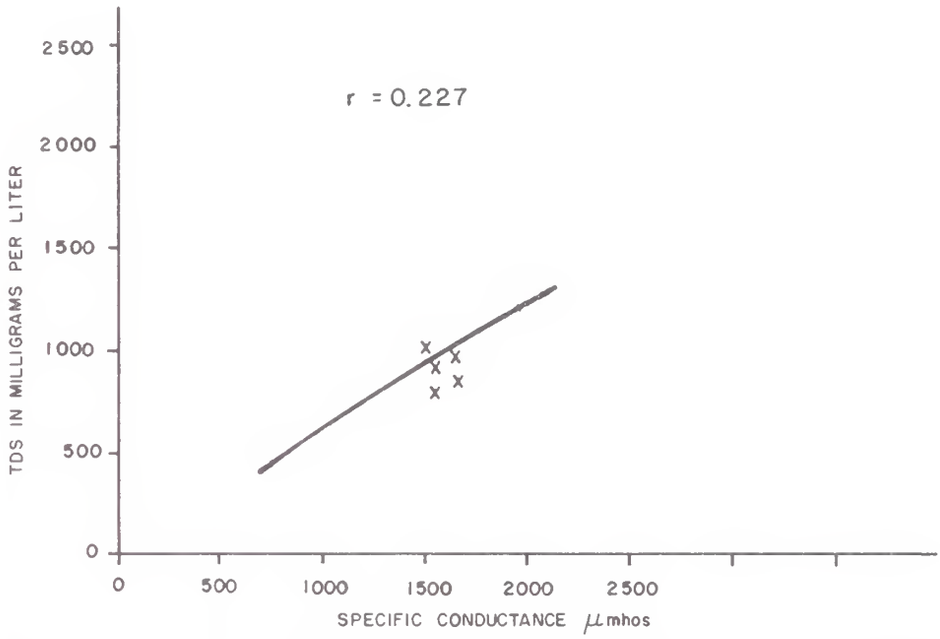
(2)



RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS WITH SULFATE AND BICARBONATE FOR EAST FORK ARMELLS CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

(3)

FIGURE 2.2-16 RELATIONSHIPS BETWEEN SELECTED CHEMICAL CONSTITUENTS FOR EAST FORK ARMELLS CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

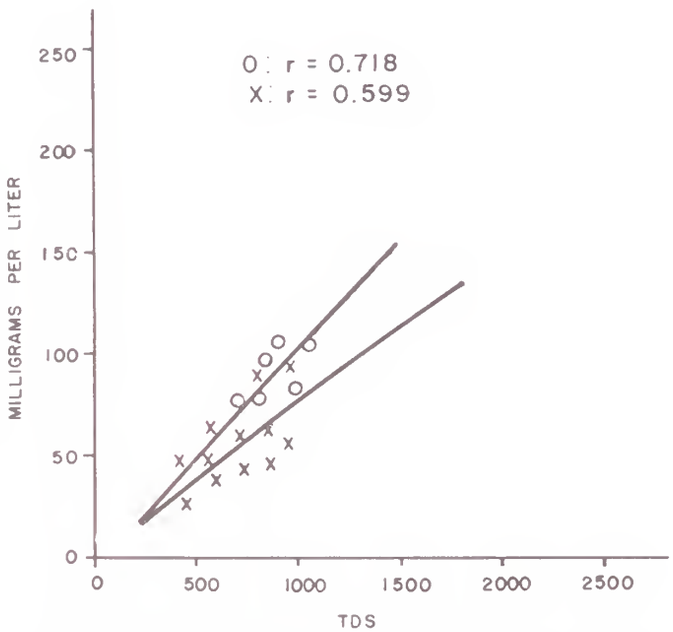


LEGEND

- GRAPH (2)
  - x SODIUM (20 SAMPLES)
  - o MAGNESIUM (20 SAMPLES)
- GRAPH (3)
  - x SULFATE (20 SAMPLES)

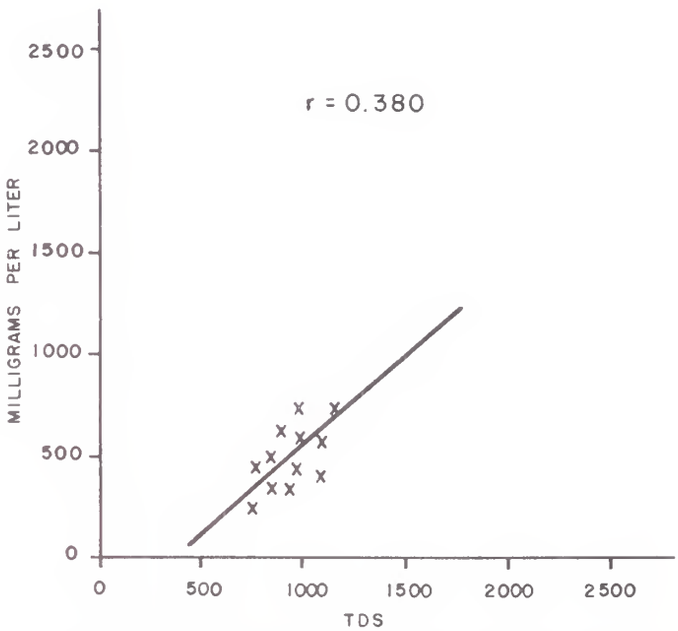
RELATIONSHIP OF SPECIFIC CONDUCTANCE TO TOTAL DISSOLVED SOLIDS FOR ROSEBUD CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

(1)



RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS AND SODIUM AND MAGNESIUM FOR ROSEBUD CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

(2)



RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS WITH SULFATE FOR ROSEBUD CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

(3)

FIGURE 2.2-17 RELATIONSHIPS BETWEEN SELECTED CHEMICAL CONSTITUENTS FOR ROSEBUD CREEK AT USGS STATION NEAR COLSTRIP, MONTANA

Trace metal concentrations in Cow Creek are at or near the detection level of analytical methodology and constitute no health problems. Boron concentrations are elevated (1.3-3.7 mg/l). According to the USEPA criterion, concentrations in excess of 3.0 mg/l may have an effect on cropland productivity.

2.2.2.5.2 Ponds

The quality of water in ponds in the Rosebud Mine area that receive runoff from disturbed and reclaimed areas of strip-mined lands is similar to that contained in the streams of the area. During spring runoff, TDS concentrations range from about 300 mg/l to about 2,000 mg/l. During summer and fall months, TDS concentrations from about 2,000 to 4,000 mg/l occur as a result of concentration from evaporation and, to a lesser extent, from inflow from subsurface drainage. These concentrations are in a range suitable for stock watering purposes.

Several farm ponds in the area have water quality similar to that found in mining areas, except during late summer and fall when they become slightly more concentrated, possibly due to farm activities or increased evapotranspiration rates.

2.2.2.5.3 Springs

Five springs are located in the Stocker Creek drainage of Area C and one has been identified near the confluence of Stocker and East Fork Armells Creeks. Two springs, SP-05 and SP-03 (Figure 2.2-3), are located in Stocker Creek valley fill. The water is highly mineralized, with TDS concentrations of 5,160 and 4,930 mg/l. The remaining three springs (SP-01, SP-02, and SP-04 in Figure 2.2-3) are located along the northern boundary of the Rosebud coal outcrop in the eastern portion of Area C. Water quality from SP-01 is similar to the valley fill springs with TDS concentration of 5,310 mg/l. Spring SP-04 has a TDS of 3,240 mg/l and spring SP-02 is of relatively good quality, with TDS of 470 mg/l. Chemical data on quality of springs are contained in Table 8, Appendix B.

The nitrate (NO_3) concentration of spring SP-02 far exceeds the normal level of waters in the area, and probably results from organic material such as livestock wastes. Trace metal concentrations were at or below analytical detection levels, except for mercury in springs SP-01 (0.230 mg/l) and SP-04 (0.010 mg/l).

One spring has been identified in permit area B. No springs have been located in areas A, D or E; however, several springs have been located outside the proposed permit areas.

Six springs are located in the South Fork Cow Creek and Cow Creek drainages. SP-13 is located 500 feet east of the mine area and has an elevated average TDS concentration of 7,390 mg/l, indicating that poorer quality spoils water may be moving into the Rosebud aquifer and discharging to Cow Creek. The TDS concentration for SP-12 is 4,690 mg/l. This spring

has an alluvial source and may be representative of groundwater quality for the area. The remaining four springs, include SP-14 (2,970 mg/l TDS), SP-16 (2,740 mg/l TDS), SP-17 (3,200 mg/l TDS) and SP-18 (2,820 mg/l TDS).

2.2.2.6 Surface Water Use

Surface water in East Fork Armells and Rosebud Creeks is used for stock water and for irrigation. There are no municipal or commercial uses of surface water from the East Fork Armells Creek in the immediate vicinity of Colstrip. Stocker and Pony Creek surface flows are used for stock watering only, whereas surface flows in Cow Creek are used for stock watering and flood irrigation of hayfields and pastures. These irrigated fields occupy an area of approximately 190 acres (0.30 square mile).

Water is imported via a 29-mile pipeline from the Yellowstone River at a potential maximum rate of 10,000 gallons per minute for municipal and commercial use by the town of Colstrip, mining activities, and the Montana Power Company (MPC) power plant. A 112-acre surge (storage) pond with a capacity of 2,250 acre-feet stores this imported water. Seepage rates from the surge pond are estimated to range from 175 acre-feet per year (Technical Support Document, Section B.1), to 180 acre-feet per year (Hydrometrics, 1981).

The MPC power plant complex uses approximately 90 to 95 percent (or 7,700 acre-feet) of the surge pond water per year. Approximately 85 percent of the water used at the power plant is lost through evaporation from cooling processes and pond surfaces; some water is lost from pond seepage, and the balance is used for road watering for dust suppression. From March through October, approximately 400 acre-feet of water is used for dust suppression. Most of this water is lost through evaporation.

Municipal water use at Colstrip is approximately 630 acre-feet of surge pond water per year, given the present (1980) population. Large amounts of this water are used during the summer months for household and community irrigation. Waste water from approximately 1,150 housing units in Colstrip is treated and released into East Fork Armells Creek (Hydrometrics, 1981). The treated discharge ranges from 17 acre-feet per month to 23 acre-feet per month. This discharge is an additional potential contributing factor to a rise in the local water table and may also have downstream effects.

There is a downstream rise in valley fill groundwater levels and an increase in surface flow near Colstrip due to seepage from the surge pond, fly ash ponds, power plant ponds and sewage effluent discharges. The total estimated seepage is 464 acre-feet per year (Hydrometrics, 1981). Of this total volume, 210 acre-feet per year is from the sewage treatment plant seepage; the rest is from the other listed sources. The addition of this volume of water will increase surface flows and recharge (Section 2.2.1.2.3).

HYDROLOGY GLOSSARY

Aggradation: The building up of the grade or slope of a stream by the deposition of sediment.

Alluvium (alluvial): A general term for clay, silt, sand, gravel or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water.

Aquifer: Stratum or zone that contains sufficient saturated permeable material to produce water in a well or spring.

Base flow: The sustained runoff of a stream system, primarily composed of effluent groundwater; the natural flow of a stream unaffected by peaks due to storms, snowmelt, or the works of man.

Base level: The lowest level to which erosion of the Earth's surface constantly progresses; the level below which a stream cannot erode its bed; the level at which stream equilibrium exists.

Boundary: (As it refers to hydrology) Indicates or fixes a limit of lower permeability that affects the hydraulic characteristics of a system, i.e., faults, springs, creeks.

Clinker: (Porcelanite) - Fused shales and clay that occur as a result of burned coal seams.

Colluvium (colluvial): A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and moved chiefly by the force of gravity.

Confined: Refers to a groundwater aquifer under sufficient hydrostatic pressure to rise above the surface of the aquifer when penetrated by a well and bounded by an impervious stratum directly above or below the zone bearing water.

Crop out: To appear exposed and visible at the surface of the Earth.

Dip: The angle that a bedding plane makes with the horizontal.

Discharge area: An area in which subsurface water, including both groundwater and vadose* water is discharged to the land surface, to bodies of surface water, or to the atmosphere.

Electrical Conductivity (EC): A measure of the ability of a solution to conduct an electrical current, measured in millimhos. It is used on soil extracts as a measure of the soluble salts in soils. Dissolved solids concentration in spoils water, measured in milligrams per liter is locally related to electrical conductivity of pre-mining overburden extracts.

Energy grade line: A line joining the elevations of the energy heads of a stream when referred to the streambed.

Ephemeral stream: A stream or portion of a stream that flows only in response to precipitation. Its channel is at all times above the water table.

Erosion rates: The amount of soil loss per unit of land area over a given time.

Evapotranspiration: Loss of water from a land area through the transpiration of plants and evaporation from the soil.

Flexure: A fold; a monocline formed by warping or other gentle deformation rather than by compression.

Gaining stream: A stream or reach of a stream that receives water from a zone of saturation and provides base flow; its channel lies below the water table.

Hardness of water: A physical-chemical characteristic that is commonly recognized by the increased quantity of soap required to produce a lather. It is mainly attributable to the presence of calcium and magnesium and is expressed as equivalent calcium carbonate ($CaCO_3$) in milligrams per liter.

Hummocky: With rounded or conical knolls, mounds, hillocks, generally of equidimensional shape and not ridgelike.

Hydraulic conductivity: The rate of flow of water through a 1-square-foot cross section under a unit hydraulic gradient, measured in feet per day.

Hydraulic gradient: In an aquifer, the rate of change of pressure head per unit distance of flow; in a stream, the slope of the "energy grade line.*"

Hydrogen-ion concentration (pH): Indicates the degree of acidity or alkalinity of water and is expressed in terms of pH units. The pH value of a solution is the negative logarithm of the concentration of hydrogen ions, in moles per liter.

Interburden: At the Rosebud and Big Sky Mines, Montana, the consolidated material that separates the Rosebud and McKay coal beds.

Intermittent stream: A stream that does not flow continuously. Flow occurs in response to precipitation, snowmelt, and groundwater inflow.

Knickpoint: Points of abrupt change in the logitudinal profile* of stream valleys.

Longitudinal profile: The surface of a valley bottom or stream, drawn along its length from the source to the mouth of the stream.

Losing Stream: A stream or reach of a stream that contributes water to the zone of saturation; its channel lies above the water table.

Milligrams per liter (mg/l): A unit expressing the concentration of chemical constituents in solution. Milligrams per liter represents the weight of solute per unit volume of water.

Normal fault: A fault in which the hanging wall (or overlaying side) appears to have moved downward relative to the footwall (or underlying side).

Outcrop: The exposure of bedrock or strata at the surface of the Earth.

Overburden: Consolidated or unconsolidated material that overlies a coal bed.

Permeability: The capacity of porous rock, sediment, or soil for transmitting a fluid.

pH: See hydrogen-ion concentration.

Porosity: The percentage of bulk volume of rock or soil occupied by pores.

Potentiometric: Refers to an imaginary surface representing the static head of groundwater, defined by the level to which water will rise in a well.

Recharge area: An area in which water is absorbed that eventually reaches the zone of saturation in one or more aquifers.

Reverse fault: A fault in which the hanging wall (or overlying side) appears to have moved upward relative to the footwall (or underlying side).

Salinity: Qualitative term expressing the soluble salt content of a solution or material.

Salinity hazard: The impact of salt content in irrigation waters on crop growth. It depends on the dissolved solids in the irrigation water, soil condition, drainage, and management practice.

Sediment yield: The actual amount of eroded material delivered by a stream system to a point in a drainage basin or subbasin.

Semi-confined: Refers to a regional groundwater aquifer that exhibits both confined and unconfined characteristics.

Sinuosity: Ratio of the length of the channel to the downvalley air distance; streams with sinuosities of greater than 1.5 are called "meandering."

Specific Conductance: A measure of the ability of water to conduct an electrical current, expressed in micromhos per centimeter at 25°C, and an indicator of degree of mineralization of water. Because the specific conductance is related to the number and type of ions in solution, it can be used for approximating the dissolved solids content in the

water. Moderate concentrations of dissolved solids in water, in mg/l (milligrams per liter), are generally numerically equivalent to about 0.7 to 0.8 times the specific conductance measured in micromhos per centimeter.

Spoils: At the Rosebud and Big Sky Mines, Montana, the reworked Rosebud coal overburden material, which has been replaced where the Rosebud coal has been mined out.

Storage coefficient: The volume of water an aquifer releases from or takes into storage, per unit surface area of the aquifer per unit change in head.

Subcrop: A buried outcrop.

Subirrigation: Supplying water to plants from underneath or from a semi-saturated or saturated zone where water is available for use by vegetation.

Terrace: Horizontal or gently inclined, relatively flat surfaces which are bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.

Total Dissolved Solids (TDS): The quantity of dissolved constituents in water; the residue of evaporation or the sum of determined constituents; results are usually reported in milligrams per liter (mg/l). Post-mining dissolved solids concentrations of spoils water by correlation compare with pre-mining electrical conductivity values of overburden. (See Electrical Conductivity.)

Transmission loss: The loss of streamflow to the alluvium (Syn: losing stream).

Transmissivity: Measure of the ability of an aquifer to transmit water through a unit width under hydraulic gradient, measured in gallons per day per foot (gpd/ft).

Unconfined: Refers to a groundwater aquifer that has a free water table, i.e., water not confined under pressure beneath relatively impermeable rocks.

Vadose water: Water in the zone of aeration.

Valley fill material: The unconsolidated colluvium and alluvium deposited by any agent so as to fill or partly fill a valley.

2.3 CLIMATE

Southeastern Montana, including the Colstrip area, has a continental climate. The majority of large-scale weather systems move from west to east. The Colstrip area is influenced by descending air masses, clear skies and temperature extremes. In winter, inversions predominate; in summer, radiation increases atmospheric turbulence (USGS, No date).

2.3.1 Temperature

Summers are characterized by warm days and cool nights. Oppressive hot spells are uncommon. Temperatures of 90°F or more occur about 40 days each year and can occur from May through October. The average temperature during the warmest month at Colstrip (July) is 71.5°F. During July the average maximum temperature is 89.2° F and the average minimum is 53.8°F.

During winter, temperatures generally cool to less than 15°F at night, but warm to 30°F or better during the day. An occasional cold spell will generate below zero temperatures, but these spells seldom last more than 2 or 3 days. The average temperature during the coldest month (January) is 21.0°F. During January the average maximum temperature is 34.4°F and the average minimum is 7.7°F.

The annual average temperature at Colstrip for the period 1941 to 1970 was 45.9°F.

2.3.2 Humidity

The annual average relative humidity for Colstrip was 55 percent in 1976 and 68 percent in 1977. The relative humidity has a wide daily variation, related to wide temperature and changes at relatively constant amounts of ambient moisture.

2.3.3 Precipitation

The annual average precipitation at the Colstrip National Weather Service station is 15.8 inches. Three-fourths of this falls during the April-through-September growing season. Winter precipitation is generally light, amounting to just over half an inch a month from November through February. Most of the precipitation during this time falls as snow. The average snowfall at Colstrip is 34.6 inches.

2.3.4 Severe Weather

Hailstorms are typically the most common and damaging form of severe weather in Montana and occur mainly in July and August. Floods may occur in spring and early summer as a result of the melting snowpack but are more likely due to thundershowers in late spring and summer.

2.3.5 Evaporation

The nearest National Weather Service station measuring evaporation rate is at Terry, Montana, about 90 miles northeast of Colstrip. Over a 5- to 10-year period, the average total evaporation for May through September was 40 inches. Evaporation data are not obtainable from October through April because periods of below freezing weather frequently occur.

The evaporation rate is also measured at the Absaloka Mine by Westmoreland Resources, about 25 miles west of Colstrip. During 1979 (May 7 through September 17), total evaporation measured was 35.7 inches, or about 0.42 inch per day.

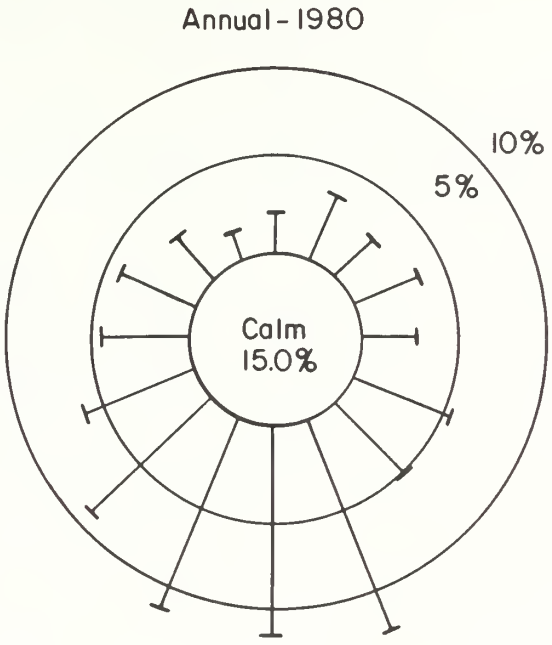
2.3.6 Dispersion Meteorology

The primary air pollutants emitted by the proposed mining operations are particulates released from ground level sources; therefore, the main meteorological characteristics that affect air pollution potential are precipitation, soil moisture content, surface wind, and mixing height. Surface wind speed determines how fast the air pollutants are removed from the area, and in the case of fugitive emissions, the amounts of air pollutants that are carried into the atmosphere. Repeated or extended stable conditions cause air pollutants to accumulate in an area. The wind direction dictates where the air pollutants are transported. Mixing height is the height above the ground to which the air pollutants are carried or mixed. If mixing heights are low, air pollutants are confined in smaller volumes and concentrations are greater.

Surface wind speed and direction are monitored by Western Energy at the meteorological station located on a ten-meter tower inside the train loop in Area A. Figure 2.3-1 summarizes the surface winds for 1980. Because southerly wind directions predominate during several of the seasons, the annual windrose also shows a predominance of southerly winds. Strongest wind speeds were from the west-southwest; slowest wind speeds were from the east. Calm conditions occurred 15 percent of the hours. Wind speeds in excess of 13 miles per hour occurred about 10 percent of the hours, but wind speeds in excess of 25 miles per hour occurred less than 1 percent of the hours.

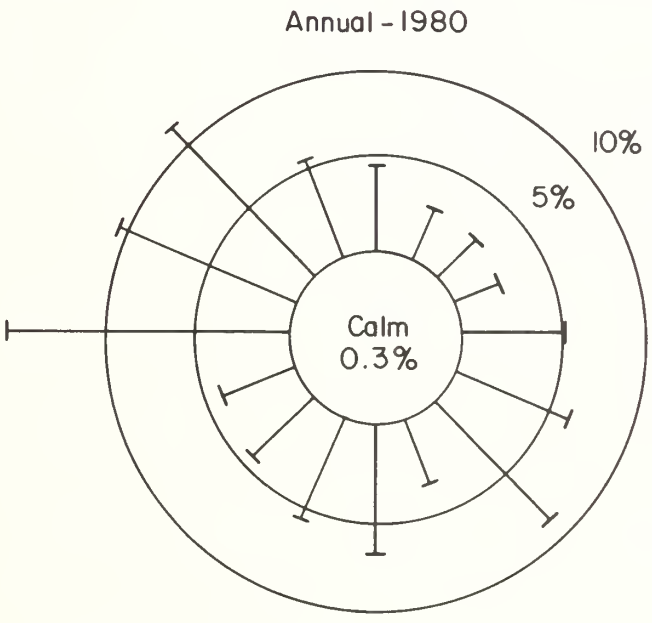
Although a wind direction shift to a more westerly direction with increased elevation is predictable, the shift of some 90 degrees from the Western Energy 10-meter site to the MPC 31 meter level is more than expected. The MPC tower is located on top of 30-meter hill, which can account for some difference. However, it appears likely that either local terrain or instrument problems account for the wind direction changes.

Mixing heights (or vertical temperature above 100 meters) have not been routinely measured in the Colstrip area. Montana State University (MSU) measured vertical temperature using aircraft in the Colstrip area during 1971-1972. Results from the MSU measurements indicated Glasgow mixing heights were similar to Colstrip heights, except during spring.



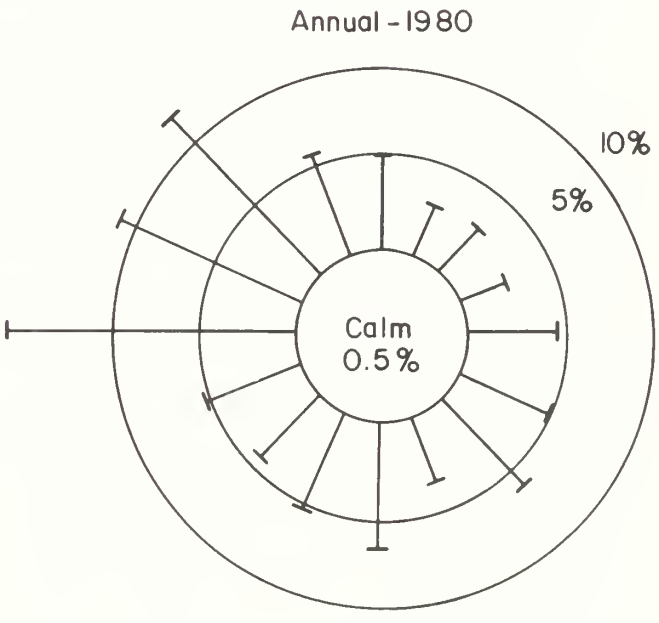
10 meters

(WESTERN ENERGY CO.)



31 meters

(MONTANA POWER CO.)



93 meters

(MONTANA POWER CO.)

FIGURE 2.3-1 COLSTRIP AREA ANNUAL WIND FREQUENCY DISTRIBUTIONS

Annually, Colstrip and Glasgow mixing heights were very similar. Holzworth (1972) reported Glasgow mixing heights as shown below.

GLASGOW, MONTANA MIXING HEIGHTS*
(Values in meters)

	Annual	Winter	Spring	Summer	Autumn
Morning	310	283	391	304	262
Afternoon	1,564	524	1,971	2,454	1,307

* Holzworth (1972)

2.4 AIR QUALITY

The following discussion is limited to particulate matter, since no other pollutants are emitted in major quantities by surface mining activity. Other, gaseous pollutants have been monitored in connection with MPC's generating Units 1 through 4, but the discussion only addresses those issues that are associated with the proposed mine operation.

2.4.1 Ambient Air Quality Standards

Air quality standards applicable to pollutant sources in the Colstrip area are those resulting from the Federal Clean Air Act and the Montana Clean Air Act. The Montana Ambient Air Quality Standards (MAAQS) and the National Ambient Air Quality Standards (NAAQS) are listed in Table 2.4-1. The NAAQS are expressed as both primary and secondary standards. Primary standards are those required, with an adequate margin of safety, to protect public health. Secondary standards are those necessary to protect the public welfare from any known or anticipated adverse effects associated with air pollutants. Standards apply only to areas of public access.

Because of the high particulate matter levels, an area of 120 square miles centered on Colstrip has been designated as a nonattainment area for total suspended particulate (TSP) (Figure 2.4-1).

2.4.2 Total Suspended Particulates

Western Energy now monitors TSP at 10 sites around Colstrip; MPC monitors TSP at 4 locations; the Montana Air Quality Bureau (AQB) formerly monitored TSP at 2 sites; and Peabody Coal Company has long-term data from 4 sites near their mining operation. The location of Western Energy's monitors is shown in Figure 2.4-1.

Examination of the data from the existing Western Energy mining areas (Western Energy Monitor sites 3, 4, 6) reveals that current levels exceed both the NAAQS and the MAAQS. Short-term concentrations as high at 6,585 micrograms per cubic meter ($\mu g/m^3$) have been recorded. The three samplers near or in Colstrip (Western Energy site 1 just southwest of Colstrip, Western Energy site 2 south of Colstrip; MPC site 3 in the center of town) generally are near or exceed the 24-hour standards. The Montana annual arithmetic standard of 75 $\mu g/m^3$ has been exceeded at all three sites, although only MPC site 3 exceeds the Federal primary annual geometric standard of 75 $\mu g/m^3$. Western Energy has recently moved its monitoring station 2 to a new location, where lower concentrations are being observed. According to a letter to the Montana Air Quality Bureau (MAQB) from Western Energy (August, 1980), Western Energy Company site 2 was moved due to realignment of the county road. The sampler was moved to Area B (from Area A) in anticipation of the need to monitor emissions from Area B that would be moving toward Colstrip. The relocation was approved by the MAQB.

The MPC data from their sampler Number 3, located in Colstrip, shows high TSP concentrations in Colstrip. Violations of both the annual and the 24-hour standard have been recorded for 3 straight years.

TABLE 2.4-1

MONTANA AND NATIONAL AIR QUALITY STANDARDS

POLLUTANT	MONTANA STANDARD	FEDERAL PRIMARY STANDARD	FEDERAL SECONDARY STANDARD
Total Suspended Particulates	75 $\mu g/m^3$ annual arithmetic average 200 $\mu g/m^3$ 24-hr average*	75 $\mu g/m^3$ annual geometric mean 260 $\mu g/m^3$ 24-hr average*	60 $\mu g/m^3$ annual geometric mean 150 $\mu g/m^3$ 24-hr average*
Sulfur Dioxide	0.02 ppm annual average 0.10 ppm 24-hr average* 0.50 ppm 1-hr average**	0.03 ppm annual average 0.14 ppm 24-hr average*	0.5 ppm 3-hr average*
Carbon Monoxide	9 ppm 8-hr average* 23 ppm hourly average*	9 ppm 8-hr average* 35 ppm 1-hr average*	9 ppm 8-hr average*
Nitrogen Dioxide	0.05 ppm annual average 0.30 ppm 1-hr average	0.05 ppm annual average	0.05 ppm annual average
Photochemical Oxidants (ozone)	0.10 hourly average*	0.12 ppm 1-hr average*	0.12 ppm 1-hr average*
Lead	1.5 $\mu g/m^3$ 90-day average	1.5 $\mu g/m^3$ calendar quarter average	None
Foliar Fluoride	35 $\mu g/g$ grazing season 50 $\mu g/g$ monthly average	None None	None None
Hydrogen Sulfide	0.05 ppm hourly average*	None	None
Settled Particulate (Dustfall)	10 gm/m^2 30-day average	None	None
Visibility	Particle scattering coefficient of 3×10^{-5} per meter annual average***	None	None

* Not to be exceeded more than once per year

$\mu g/m^3$, micrograms pollutant per cubic meter of sampled air

ppm parts pollutant per million parts of sampled

** Not to be exceeded more than 18 times per year

*** Applies to PSD Class I areas

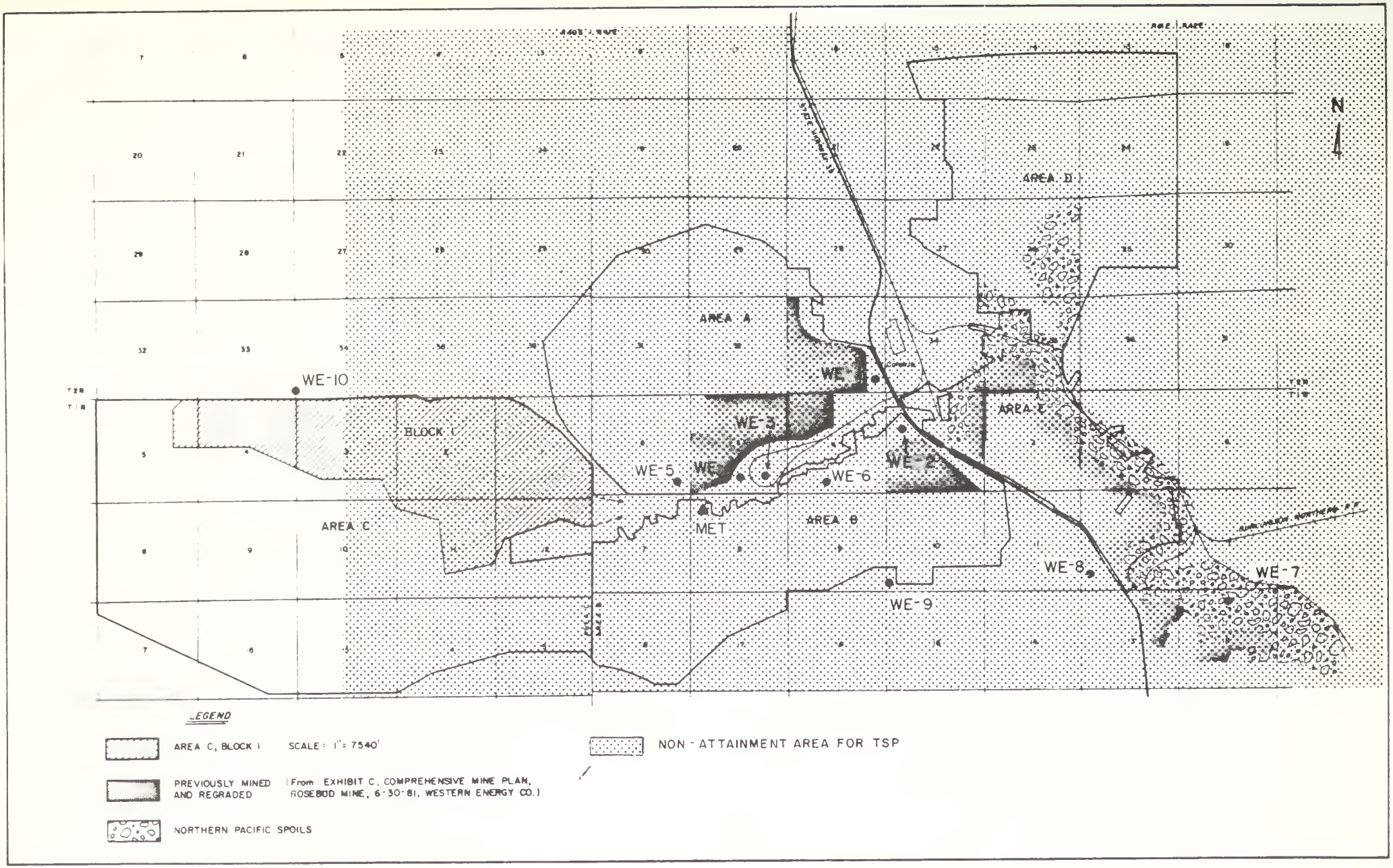


FIGURE 2.4-1 HIGH VOL. & MET. STATIONS

The samplers located out of town and away from the active mining operations reveal much lower concentrations. Western Energy samplers 5, 7, 8, 9, 10 and 11 (Sampler 11 is located 6 miles west of Sampler 10, and off the map shown in Figure 2.4-1) show values well below both annual and 24-hour standards. Similar low values were measured at the MAQB McRae site (14 miles southeast of Colstrip). Another large group of samplers shows occasional violations of the 24-hour standard but generally low concentrations (well below the annual standard). This includes three Montana Power Company Sites: one located 1 mile northwest of Colstrip, the second, 2½ half miles southeast of town, and the third, 3 miles southeast of Colstrip (MPC Numbers 1, 4, and 2). This group also includes Western Energy samplers 1 and 2, and the MAQB BN Sampler located 2½ miles southeast of Colstrip.

Because of the high particulate matter levels, an area of 120 square miles centered on Colstrip has been designated as a nonattainment area for TSP. The U.S. Environmental Protection Agency (EPA) designated the attainment status of this area and various other areas in Montana on March 3, 1978 (43 CFR 9009-9010). The State of Montana submitted a revision to the State Implementation Plan (SIP) on April 23, 1979, in which the State committed to bring the Colstrip area into compliance with both the annual and 24-hour NAAQS TSP standards by December 31, 1982. The Montana Department of Health and Environmental Sciences (MDHES) proposes to attain these standards through the enforcement of a revised airborne particulate rule by requiring existing mining operations to meet conditions of required operating permits. In the meantime, for any mine to expand in the nonattainment area, the mining company must demonstrate that it is decreasing nonfugitive particulate emissions in the area to a degree greater than will be generated by its proposed expansion. This is known as "offset" under the State and Federal air regulations. The requirements hold true for any other major plant that might be sited in the nonattainment area.

The particulate situation in the Colstrip area is characteristic of fugitive dust impacts. Because the emission sources causing the problem (e.g., mining dust, construction dust, vehicular travel on paved and unpaved surfaces, and the coal handling around the power plant) produce particulates of a relatively large size (PEDCO, 1981; TR, 1981), the dust settles out quickly and the impacts are very localized. Areas not close to any significant source generally have low concentrations. In between, there is a transition zone where concentrations are usually low but may reach occasional high short-term levels due to adverse meteorological conditions.

Fugitive dust problems of this type are relatively difficult to solve. Western Energy has in recent years undertaken a number of new dust control measures at their existing operations. A detailed discussion of these actions is provided in the EIS prepared for Area B (Montana DSL, 1980). The new measures have not significantly reduced TSP concentrations in Colstrip, partly because local sources in town (construction sites, coal-handling facilities for Units 1 and 2, and unpaved roadways) may be responsible for a sizable percentage of the impact and because the amount of emissions reduction is small when compared to total emissions.

2.4.3 Settled Particulates

Settled particulate samplers, or dustfall buckets, are now located at five of the Western Energy TSP sites. No Federal ambient standard addresses dustfall. The Montana 30-day average standard of 10 grams per square meter has been exceeded at Western Energy 3, 4, and 6, all in the train loop area. At Western Energy 7 (located in reclaimed portions of Area E) and 11 (located in Area C) dustfall amounts exceeded the Montana standard during 1981. Dustfall levels exceeded the Montana standard in the past; however, sampling at Western Energy 5 (about one-quarter of a mile southwest of Area A) and 8 ($2\frac{1}{2}$ miles southeast of Colstrip) was discontinued in 1980. The settled particulate values follow the pattern of fugitive dust areas. The large-sized particles produced by fugitive dust sources settle rapidly and generally accumulate in large quantities.

2.4.4 Visibility

An alternate method was utilized to establish existing visibility in the Colstrip area. The current impairment to visibility along two characteristic lines of sight was calculated using visibility modeling techniques described in detail in the EIS Technical Support Document (available at the Department of State Lands Office, Helena). The two lines of sight were selected based on the following considerations:

- The lines of sight should pass near or directly over the existing sources of particulate matter so that current visibility degradation can be sampled;

- The lines of sight should travel in relatively flat terrain so that long vistas can be obtained through the area where degradation is suspected; and

- The origin of each line of sight should be at a point where the public has ready access, so the model predictions will relate to typical observer experience.

The two lines of sight selected for analysis are described as follows:

- LOS1 - Originating near Castle Rock, located approximately $8\frac{1}{2}$ miles miles west of Colstrip, viewing in an east-south-eastward direction (96° east-southeast of true north). This line of sight angles upward at a rate of climb of 2.7 feet per 1,000 feet.

- LOS2 - Originating on State Highway 39, approximately $3\frac{1}{2}$ miles north of Colstrip, viewing in a south-south-eastward direction (164° south-southeast of true north). This line of sight angles upward at a rate of climb of 14.7 feet per 1,000 feet.

Existing visibility along these lines of sight was estimated by calculating the annual average visual range along the lines of sight as described in the Technical Support Document. The visual range thus calculated was 59.9 miles for LOS1 and 59.2 miles for LOS2.

2.5 NOISE

Away from areas of human activity, existing sound levels in Rosebud County are very low. Only one source of ambient sound level measurements was available. The 1979 Colstrip Project EIS (USDI, 1979) reported measurements taken at various distances from the town of Colstrip. At 3.8 miles from town, the tone radiating from the generating plant was only marginally audible at 32 dBA. Since the human ear is normally able to just begin to hear sound level increases of about 3 dBA, the authors assumed that background sound levels were approximately 29 dBA. It is not unreasonable to assume that background sound levels at other locations are also about 29 dBA.

The 1979 Colstrip Project EIS also reported sound levels in Colstrip ranging from 53 to 68 dBA. Due to the presence of the generating plant, the relatively high ambient sound level was considered more typical of an urban area than a small town.

Neither Montana nor Colstrip has specific ambient noise regulations. The Environmental Protection Agency, however, has published noise level guidelines in "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" (EPA, 1974). Since the identified sound levels consider neither cost nor technical feasibility, EPA states that its guidelines are not to be interpreted as Federal ambient noise standards, but rather as information for State and local government use in establishing their regulations. These levels are summarized in Table 2.5-1.

TABLE 2.5-1

SUMMARY OF NOISE LEVELS IDENTIFIED
AS REQUISITE TO PROTECT PUBLIC HEALTH
AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

Effect	Level	Area
Hearing loss	$L_{eq} \leq$ 70 dBA	All areas.
Outdoor activity	$L_{dn} \leq$ 55 dBA	Outdoors in residential areas, farms, and other areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq} \leq$ 55 dBA	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity intereference and annoyance	$L_{dn} \leq$ 45 dBA	Indoor residential areas.
	$L_{eq} \leq$ 45 dBA	Other indoor areas with human activities, such as schools, etc.

* In this table, L_{eq} refers to a 24-hour equivalent sound level; this is the constant sound level that has the same sound energy as a time-varying sound would over a 24-hour period. L_{dn} is a 24-hour equivalent sound level in which the nighttime (10:00 p.m. to 7:00 a.m.) sound levels are increased by 10 decibels to account for the added annoyance due to sleep interference.

2.6 SOILS

The soils of the Rosebud mine are predominantly light-colored soils with weakly developed subsoils and thin dark-colored surface layers (Aridisols). Less common soils in the area include poorly developed soils (Entisols) in which very little alteration from the underlying material has occurred (Soil Survey Staff, 1975). The textures and depths of the soils are strongly influenced by the geologic materials they are formed in and by the processes responsible for their deposition.

A wide range of soils occur at the mine, from shallow stony soils formed in clinker to deep clayey soils formed in alluvium along intermittent streams. The soils of the area can be divided into four major groups:

- o Sandy Residual Soils
- o Alluvial Loamy and Clayey Soils
- o Clinker Soils
- o Unbaked Shale and Siltstone Soils

Each group represents several soil mapping units recognized in detailed soil mapping. Groups were developed to represent soils occupying similar landscape positions and having similar characteristics. Figure 2.6-1 shows the distribution of soil groups for the Rosebud Mine. As with any generalized information, it can be assumed that some soils atypical for the group will be encountered within each general soil group.

The sandy residual soils are formed in material weathered from the weakly cemented sandstones of the Tongue River Member of the Fort Union Formation. Depth to sandstone ranges from 20 to 40 inches in ridgetop positions to greater than 60 inches in toeslope positions. This soil group characteristically occurs in smooth, rolling topography. Typical vegetation includes small clumps of ponderosa pine (Pinus ponderosa) along ridges, where soils are shallow to sandstone, and extensive areas of mid and tall grasses with scattered skunkbush sumac (Rhus trilobata) and yucca (Yucca glauca).

The alluvial loamy and clayey soils occur in a majority of the valleys adacent to intermittent streams. These soils are also found in swales between hills and ridges. The soils have been deposited by streams and by slope-wash processess and have textures ranging from loam to clay. Trees are uncommon and are found only along major streams. Characteristic vegetation of the unit includes mid-grasses and sagebrush (Artemisia tridentata and A. cana). A majority of the cultivated land in the area occurs in the gently sloping portions of this soil group. No prime farmland has been identified at the Rosebud Mine (SCS, 1978).

The clinker soils are easily identified by their reddish and purplish colors. They commonly occur along ridgetops and crests of rolling hills, and usually support healthy stands of ponderosa pines. The soils are generally very gravelly and sometimes cobbly; fractured rock is commonly encountered within 40 inches. The characteristics of all soils included in this group are relatively consistent, dominated by the high component of hard-rock fragments.

R40E | R41E

R41E | R42E

AREA D

N

LEGEND

SCALE 1"= 2580'

ALLUVIAL SOILS

SANDY SOILS

CLINKER SOILS

UNBURNED SHALE AND SILTSTONE SOILS

OLD BURLINGTON NORTHERN SPOILS

PREVIOUSLY MINED AND REGRADED BY WESTERN ENERGY COMPANY

PROPOSED CONVEYOR ROUTE

39

AREA A

Colstrip

AREA C

T2N
T1N

T2N
T1N

AREA E

BURLINGTON NORTHERN R.R

AREA B

39

PIT 6

FIGURE 2.6-1 GENERAL SOILS MAP, ROSEBUD MINE

The unbaked shale and siltstone soils, on the other hand, are the most variable groups of soils recognized at the Rosebud Mine. They are commonly weakly developed (Entisols) and occur in complex, dissected, hilly areas. Rock is commonly encountered within 40 inches of the surface. Textures of the soils in this group range from gravelly sandy loam to clay and are strongly influenced by the variability of the interbedded shales and siltstones of the Fort Union Formation. Vegetation, which appears to be strongly influenced by topography, ranges from sparsely vegetated areas covered by junipers (Juniperus scopulorum) and rabbitbrush (Chrysothamnus nauseosus) to well-developed stands of ponderosa pine.

No prime farmland soils have been identified in any of the proposed disturbance areas at the Rosebud Mine (Lewis Daniels, 1978).

2.6.1 Area A

Area A is located in the north-central portion of the Rosebud Mine. The proposed boundary encloses an area of approximately 4,324 acres. This area includes both disturbed and undisturbed portions, listed in Table 2.6-1.

Mining has been completed in the southeastern quadrant of the area, disturbing a total of about 1,140 acres. Of these, approximately 805 acres are being reclaimed, 236 acres continue to support surface disturbances, such as roads and powerlines, 93 acres are being converted for townsite expansion, and about 6 acres of unreclaimed highwall remain along the western boundary.

The most prevalent soil group in the undisturbed area is the unbaked shale and siltstone group, occupying 43 percent of the area. Alluvial loamy and clayey soils occupy 34 percent of the area, occurring mostly in lower topographic positions in the southern half of the area. Clinker soils occupy 14.5 percent of the area and occur along the outer boundary of the area. Sandy residual soils occupy 8.5 percent of the area and are intermingled with the other soil groups.

The soils in Area A influence the vegetative types occurring there. These are discussed in detail in Section 2.7. Conifer-shrubland types occur on almost all of the clinker soils and on about one-third of the unbaked shale and siltstone soil group. The remaining area of unbaked shale and siltstone soils are covered by shrub-grassland vegetation. Grassland and cropland areas are concentrated in the southern portion of Area A, corresponding to the large areas of alluvial loamy and clayey soils.

2.6.2 Area B

Area B is located in the south-central portion of the Rosebud Mine. The proposed boundary, including all extensions, encloses an area of approximately 3,438 acres. Mining is actively occurring in the eastern half of the area. As of June 1981, 403 acres had been disturbed, including 213

TABLE 2.6-1

SOIL DISTRIBUTION, AREA A

TOTAL AREA WITHIN PROPOSED AND EXISTING PERMIT BOUNDARIES - 4,324 acres				
UNDISTURBED 3,184 acres			DISTURBED (6/81) 1,140 acres	
Soil Group	Area (acres)	Undisturbed Percentage	Type of Disturbance	Area (acres)
Sandy Residual Soils	272	8.5%	Previously Mined and Regraded	805
Alluvial Loamy and Clayey Soils	1,093	34.0%	Remaining Highwall	6
Clinker Soils	463	14.5%	Ongoing Surface Disturbance	236
Unbaked Shale and Siltstone Soils	1,356	43.0%	Townsite Expansion	93

acres that were being reclaimed and 190 acres that had ongoing surface disturbances.

Of the undisturbed portion of Area B, the alluvial loamy and clayey soils occupy the highest proportion: 46 percent of the area (Figure 2.6-1). Sandy residual soils occur on a majority of the rolling hillslopes, occupying 32 percent of the area. Unbaked shale and siltstone soils occupy 20 percent of the area, primarily in the southwestern corner. A small percentage (2 percent) of clinker soils also occur in Area B. Table 2.6-2 lists the acreages of all these soil types.

The topography of Area B is relatively subdued with some hilly portions along the southern boundary. Conifer-shrubland vegetation occupies a minor percentage of the area, 3 percent (Section 2.7), and occurs on the unbaked shale and siltstone soils and the minor areas of clinker soils.

2.6.3 Area C

Area C, the westernmost portion of the Rosebud Mine, occupies approximately 8,332 acres. The area is crossed by East Fork Armells Creek and serves as a portion of the headwaters for Stocker Creek.

None of Area C has been previously disturbed by coal mining activities. Some minor surface disturbances have occurred due to the mining of clinker (scoria) for roadbase.

Alluvial loamy and clayey soils make up the highest percentage of soils in the area: approximately 53 percent. They occur along the major valley system associated with East Fork Armells Creek and, to a lesser degree, with the valley areas of the Stocker Creek drainage.

Two ridge systems cross the area, one along the southern edge and another crossing the center from northeast to the west. Unbaked shale and siltstone soils occur along the highest portion of both ridge systems, and the rolling hills flanking the ridges are made up primarily of the sandy residual soils.

Sandy residual soils make up 27 percent of the area, and unbaked shale and siltstone soils make up 16 percent.

Clinker soils cap many of the hills along the northern edge of the area and make up about 4 percent of the area. The acreages of each major soil group for Area C are listed in Table 2.6-3.

Vegetation correlates with the soil types in patterns similar to the other portions of the Rosebud Mine. Conifers grow on almost all clinker soils and in some portions of the unbaked shale and siltstone soils. In Area C, conifers also occur on scattered ridgetops of sandy soils. Shrub-grassland vegetation, dominated by sagebrush, occurs predominantly on the alluvial loamy and clayey soils, while the grassland types occur primarily on the sandy soils. Area C supports the highest proportion of intensive

TABLE 2.6-2

SOIL DISTRIBUTION, AREA B

TOTAL AREA WITHIN PROPOSED AND EXISTING PERMIT BOUNDARIES - 3,438 acres

UNDISTURBED 3,035 acres			DISTURBED (6/81) 403 acres	
Soil Group	Area (acres)	Undisturbed Percentage	Type of Disturbance	Area (acres)
Sandy Residual Soils	978	32.2%	Previously Mined and Reclaimed	213
Alluvial Loamy and Clayey Soils	1,405	46.3%		
Clinker Soils	58	1.9%	Ongoing Surface Disturbance	190
Unbaked Shale and Siltstone Soils	594	19.6%		

TABLE 2.6-3

SOIL DISTRIBUTION, AREA C

TOTAL AREA WITHIN PROPOSED AND EXISTING PERMIT BOUNDARIES - 8,332 acres		
Soil Group	Area (acres)	Percentage of Undisturbed
Sandy Residual Soils	2,245	27.0%
Alluvial Loamy and Clayey Soils	4,436	53.2%
Clinker Soils	360	4.3%
Unbaked Shale and Siltstone Soils	1,291	15.5%

agricultural activity at the Rosebud Mine: 9 percent of the area supports small-grain crops and 8 percent of the area is used for hay production (Section 2.10). The high percentage of gently sloping alluvial loamy and clayey soils in the area appears to influence this pattern.

2.6.4 Area D

Area D is located in the northeastern corner of the proposed Rosebud Mine area. The area is topographically complex and serves as the headwaters to intermittent tributaries to Cow Creek, Pony Creek, Spring Creek, and East Fork Armells Creek. The proposed boundary encloses an area of approximately 3,636 acres. This includes areas disturbed by earlier mining (273 acres) and undisturbed areas (3,363 acres) (Figure 2.6-1).

The old spoils remaining from mining by Northern Pacific lie in the south-central part of the proposed area. Reclamation, consisting of leveling the tops of about one-third of the spoil ridges, was carried out after this earlier mining; however, no topsoil was applied, and no attempt was made to return the spoils to the original contour of the land.

The soils on the old spoils, similar to the old spoils at Pit 6 and Area E, are weakly developed, having been exposed to weathering and soil-forming processes for the last 50 years or less. Calcium carbonate is evenly distributed throughout these soils, and rock fragments of shale, sandstone and siltstone are common below the first foot of spoils. Above this depth, most of the fragments of the poorly lithified rocks have been weathered sufficiently to be considered soil (Schafer et al., 1979a). Some limited areas that are extremely acid can be expected to occur in these old spoils, formed from the oxidation of pyrites contained in the overburden. Other areas with high electrical conductivities can be anticipated to occur. Schafer et al. (1979b) found both conditions in the old spoils.

Of the undisturbed portions of Area D (3,363 acres), the most prevalent soil group is the sandy residual soils, occupying 33 percent of the area. These are concentrated in the southern part of the area, along the flanks of hills. Unbaked shale and siltstone soils occupy 29 percent of the area and are concentrated in the central part. Alluvial soils make up 22 percent, and clinker soils make up 16 percent, of the area. Table 2.6-4 lists the acreages supporting these percentages.

A limited amount of the area is used for small-grain crop production (5 percent, see Section 2.10), and this occurs on the alluvial soil group. Conifers are widespread in Area D, occurring on most of the clinker soils, some of the sandy residual soils, and a high percentage of the unbaked shale and siltstone soils.

The consistent occurrence of the conifer-shrubland type on the unbaked shale and siltstone soil group in Area D differs somewhat from the sporadic conifer distribution on these soils in the other permit areas of the Rosebud Mine. This may be due to an historic absence of fire, decreased use of the area by man and livestock, or other outside influences on the forested portions of the area. It is also likely that local variations in

TABLE 2.6-4

SOIL DISTRIBUTION, AREA D

TOTAL AREA WITHIN PROPOSED AND EXISTING PERMIT BOUNDARIES - 3,636 acres				
UNDISTURBED 3,363 acres			DISTURBED (6/81) 273 acres	
Soil Group	Area (acres)	Undisturbed Percentage	Type of Disturbance	Area (acres)
Sandy Residual Soils	1,110	33.0%	Area Disturbed by Burlington Northern Mining, Not Reclaimed	273
Alluvial Loamy and Clayey Soils	752	22.4%		
Clinker Soils	545	16.2%		
Unbaked Shale and Siltstone Soils	956	28.4%		

precipitation patterns, wind, distribution of snow, or rock and soil characteristics have made deep soil moisture more available in Area D, favoring the regeneration and survival of the conifers.

2.6.5 Area E

Area E is bounded on the north, east, and west by old spoils remaining from mining by Northern Pacific. The total area enclosed by the permit boundary of Area E is 1,896 acres. Of this, 1,276 acres were disturbed by mining as of June 1981, including 805 acres of old Northern Pacific spoils and 471 acres of land mined by Western Energy. Much of this disturbed land has been regraded and reclaimed.

Six-hundred and twenty acres remained undisturbed as of June 1981 in Area E. Sandy soils make up 44 percent of this area; alluvial soils, 30 percent; unbaked shale and siltstone soils, 23 percent; and clinker soils, 3 percent (Table 2.6-5).

Shrub-grassland vegetation occurs on both the alluvial soils and sandy residual soils. The grassland vegetation type occurs on a portion of the alluvial soils. A small acreage of the conifer-shrubland vegetation type occurs on the unbaked shale and siltstone soils and on a narrow ridge associated with the sandy residual soils.

No clear correlation of Area E vegetative types with soils is apparent. This may be due to previous mining or the small size of the area, which obscures the correlation. Even so, the conifer-shrubland type does correlate with soils that are shallow or moderately deep to rock, a pattern consistent with other mine areas.

2.6.6 Conveyor Corridor

Most soils along the corridor route are included in the alluvial loamy and clayey soil group. Of the 226 acres along the route, approximately 131 acres have not been disturbed by previous mining and road construction activities. Vegetation includes grassland, shrub-grassland, and cropland. The railroad loop is being irrigated and used for hay production. Work by investigators of the Montana Department of State Lands indicates that the soil characteristics of the railroad loop field are unusual, being moderately deep sandy loam over less permeable silt loams and silty clay loams, which encourages the retention of soil moisture and the production of hay..

TABLE 2.6-5

SOIL DISTRIBUTION, AREA E

TOTAL AREA WITHIN PROPOSED AND EXISTING PERMIT BOUNDARIES - 1,896 acres

UNDISTURBED 620 acres			DISTURBED (6/81) 1,276 acres	
Soil Group	Area (acres)	Undisturbed Percentage	Type of Disturbance	Area (acres)
Sandy Residual Soils	274	44.2%	Old Burlington Northern Spoils, Regraded and Being Reclaimed	805
Alluvial Loamy and Clayey Soils	186	30.0%	Areas Previously Mined and Regraded by Western Energy Co.	471
Clinker Soils	19	3.1%		
Unbaked Shale and Siltstone Soils	141	22.7%		

2.7 VEGETATION

Four basic native vegetative types have been delineated in the Rosebud Mine area: grassland, shrub-grassland, riparian, and conifer-shrubland. The four native types are differentiated by major growth form and landscape position. The grassland and shrub-grassland communities comprise an association of northern mixed prairie and occur primarily on flat or gently sloping terrain. Riparian communities, limited in extent, are associated with springs and ephemeral to intermittent drainages. Conifer-shrubland communities are found on ridges and adjacent upper slopes in conjunction with siltstone and shale outcrops and clinker (scoria). In addition to the four native communities, two introduced vegetative types--cropland and disturbed grassland--have also been delineated. Areas A, B, C, D, and E vary in how much of each vegetative community they contain. (See Figure 2.7-1 and Table 2.7-1).

TABLE 2.7-1
VEGETATION, AREAS A THROUGH E

Vegetation Type*	Acreage A	B	C	D	E
Grassland	876	1,323	3,339	1,273	89
Shrub-grassland	1,257	1,155	2,879	499	416
Conifer-shrubland	807	107	512	1,415	52
Disturbed grassland	51	334	131	0	63
Cropland	193	116	1,471	176	0
Northern Pacific Spoils	0	0	0	273	805

*does not include reclamation or current disturbance areas

The four native vegetative types have been delineated from Western Energy Company's vegetation studies. These studies identified a number of native plant communities at the Rosebud Mine. The communities were named according to two or three dominant plant species at the time of examination. This approach names vegetative communities based on the species dominant when examined. Although the technique is standardized, it would reveal different dominant species at different times in relation to climatic conditions and land use. Some dominant and co-dominant plant species have already changed for some communities in just 6 years.

To provide more basic ecological data for reclamation and management, the four native and two introduced plant communities are compared with the

R40E | R41E

R41E | R42E

AREA D

N

LEGEND

SCALE 1"=4693'

- GRASSLAND
- SHRUB — GRASSLAND
- CONIFER-SHRUBLAND
- DISTURBED GRASSLAND
- CROPLAND
- OLD NORTHERN PACIFIC SPOILS
- PREVIOUSLY MINED AND REGRADED BY WESTERN ENERGY COMPANY
- PROPOSED CONVEYOR ROUTE
- RIPARIAN (Areas of shrub/tree concentrations along major drainages based on 1:24,000 air photos.)

AREA A

39

Colstrip

T2N
T1N

T2N
T1N

AREA E

BURLINGTON NORTHERN R.R

AREA B

39

PIT 6

AREA C

FIGURE 2.7-1 GENERAL VEGETATION MAP, ROSEBUD MINE

potential, or climax, communities of equivalent rangesites, as described by the Soil Conservation Service in the Montana Technical Guide, Section II-3 (USDA-SCS, 1981). A rangesite is defined as a distinctive kind of rangeland that differs from other kinds of rangeland in its ability to produce a characteristic, natural, climax community (USDA-SCS, 1977).

The grassland community type covers about 32 percent of the Rosebud Mine area. This type occupies several rangesites, the dominant two being silty and sandy. The dominant climax species on the silty sites are western wheatgrass (Agropyron smithii), thickspike wheatgrass (Agropyron dasystachyum), bluebunch wheatgrass (Agropyron spicatum), and needle-and-thread (Stipa comata), all cool-season grasses. The dominant climax species on the sandy sites are prairie sandreed (Calamovilfa longifolia), little bluestem (Schizachyrium scoparium), and big bluestem (Andropogon gerardii), all warm-season grasses. Needle-and-thread and thickspike wheatgrass, two cool-season grasses, are also important species in the climax community of the sandy site. These grass species are now found in the Rosebud Mine area in varying amounts, depending on range condition. Other species now growing in relative abundance include blue grama (Bouteloua gracilis), sedges (Carex spp.), prairie junegrass (Koelaria macrantha), and intermixed pockets of yucca (Yucca glauca).

The shrub-grassland type occurs primarily on the silty, sandy, and clayey rangesites. This type includes three communities; each is dominated by a different shrub: big sagebrush (Artemisia tridentata), silver sagebrush (Artemisia cana), or rubber rabbitbrush (Chrysothamnus nauseosus). The shrub-grassland vegetative type occupies about 22 percent of the rangeland in the mine area. At present, shrubs dominate the shrub-grassland communities. In the climax communities, in contrast, shrubs account for less than 10 percent of the annual vegetative production.

In the shrub-grassland communities, big sagebrush is the dominant shrub species on uplands. Bluebunch wheatgrass, needle-and-thread, and other native cool-season grasses grow in association with big sagebrush. In swales and on benches, silver sagebrush is the dominant shrub. Skunkbush sumac (Rhus trilobata), western snowberry (Symphoricarpos occidentalis), and big sagebrush occur in association with the silver sagebrush. Numerous forb species are also present. Western wheatgrass and Kentucky bluegrass (Poa pratensis) are abundant. Cool-season grasses account for nearly two-thirds of the vegetative canopy. In steeper portions of the shrub-grassland, rubber rabbitbrush dominates minor areas.

The riparian type occupies overflow, wetland, and subirrigated rangesites. Dominant species are deciduous trees and shrubs, including boxelder (Acer negundo), green ash (Fraxinus pennsylvanica), chokecherry (Prunus virginiana), hawthorn (Crataegus spp.), American plum (Prunus americana), and snowberry. Kentucky bluegrass, western wheatgrass, and sedges are important understory species.

The conifer-shrubland community occupies about 13 percent of the Rosebud Mine area. Ponderosa pine (Pinus ponderosa), in scattered to moderately dense stands with adjacent areas of skunkbush sumac and Rocky

Mountain juniper (Juniperus scopularum), are characteristic of this community. Pine stands are usually confined to north-facing slopes, although some trees extend onto south-facing slopes where suitable microsites and reduced competition due to grazing exist. Stand density ranges from 32 to 360 trees per acre (Western Energy, 1980). Individual stands of pine range from 40 to 75 years of age. Most mature trees are between 26 to 30 feet tall (Western Energy, 1978a). The predicted height at 100 years of age is about 49 feet (Western Energy, 1978).

The conifer-shrubland community is generally found on rocky, shallow to moderately deep soils often associated with weakly consolidated sandstone or clinker outcrops. The presence of pine appears to be favored by soils having rapid infiltration and percolation rates and related impermeable zones. Ponderosa pines tend to be shallow-rooted in the Colstrip area. Stout (1980) found only one tree with a tap root, which extended 46 inches. Most roots tend to be concentrated in the upper 18 inches of the soil. Maximum depths of lateral roots ranged from 11 to 48 inches (Stout, 1980). Canopy cover of the understory and open areas consists of a variety of the grasses, forbs, and shrubs mentioned above.

Most of the 436 acres of cropland in the Rosebud Mine area are used primarily for production of winter wheat in a wheat-fallow cropping system. A majority of these areas occur on silty and clayey rangesites. Vegetative cover is provided by either the wheat crop, the standing stubble after harvest, or crop residues remaining after summer fallow tillage. Another major crop is hay, either alfalfa (Medicago sativa) or a mixture of crested wheatgrass (Agropyron cristatum) and alfalfa. These crops are used for winter feed or spring-fall grazing.

2.7.1 Range Condition and Stocking Rates

Range condition is the state of vegetation in relation to climax (natural potential). Conditions may be excellent, good, fair, or poor, depending upon the degree that the present plant community reflects the climax. The primary measure of range condition is based on the composition by weight of the species present. Rangeland in fair condition has a vegetational composition consisting of 25 to 50 percent of the expected climax composition, while rangeland in good condition contains 50 to 75 percent of the climax composition. It should be noted that sites in lower range condition classes may produce greater total biomass than sites in the climax condition. This occurs when invader, or secondary, climax species dominate a site because conditions are favorable for their growth. Overall range condition throughout the mine area is estimated to be fair, although isolated areas may be in good condition.

Range production can be expressed in terms of animal-unit-months (AUM's) and is based on range condition and rangesites. (An AUM is the amount of forage required by one mature, 1,000-pound cow, with or without an unweaned calf at side, or the equivalent, for 1 month). Range in fair condition varies from 0.15 AUM per acre in grassland and shrub-grassland areas to 0.2 AUM per acre in some conifer-shrubland areas.

2.7.2 Threatened and Endangered Species

No threatened or endangered plant species were identified at the Rosebud Mine.

2.8 WILDLIFE

An extensive amount of information is available on the wildlife of the Rosebud Mine. Western Energy has sponsored wildlife investigation programs since before 1973. Data have been collected on big game, upland game birds, raptorial birds, songbirds, waterfowl, mammalian predators, small mammals, and reptiles and amphibians. The study area is shown in Figure 1, Appendix D.

Mining in Colstrip prior to 1973 was not subject to reclamation requirements; consequently, most reclamation has been recent. Areas A, B, and E have active reclamation plans designed to rehabilitate disturbed lands to productive condition. It is unknown what effect, if any, past and ongoing mining activities may have had on the wildlife populations of the area. The destruction of habitat by mining and related surface developments may have decreased the maximum potential wildlife carrying capacity of the area. The increased exposure of wildlife to human activities may have adversely affected survivorship and production of wildlife. But the actual impact of such changes is unknown.

Habitat types currently found at the Rosebud Mine include grassland, shrub-grassland, conifer-shrubland, agriculture and reclaimed land. The grassland habitat type (see Section 2.7) provides food, cover, and shelter for such species as the horned lark (Eremophila alpestris), savannah sparrow (Passerculus sandwichensis), golden eagle (Aquila crysaetos), sharp-tailed grouse (Pediocetes phasianellus), black-tailed prairie dog (Cynomys ludovicianus), coyote (Canis latrans) and pronghorn (Antilocapra americana). The grassland habitat type generally provides summer range for pronghorn, although many species occur year-round.

Shrub-grasslands composed primarily of sagebrush are another major habitat type found at the Rosebud Mine. They provide necessary nesting cover for Brewer's sparrow (Spizella breweri) and mourning dove (Zenaida macroura) and are used particularly in the winter by pronghorn, mule deer (Odocoileus hemionus), and sage grouse (Centrocerus urophasianus). They also provide a means of escape from predators for many small mammals and birds.

The conifer-shrubland habitat type consists mostly of ponderosa pine (see Section 2.7). This habitat type is used by mule deer, Merriam's turkey (Meleagris gallopavo), bobcat (Lynx rufus), and a variety of songbirds and small mammals.

Agricultural areas may be used by such species as the ring-necked pheasant (Phasianus colchicus) and by small mammals, such as the the deermouse (Peromyscus maniculatus). Additionally, food is provided by this habitat type to various songbirds.

Species using the reclaimed areas can be expected to be similar to those associated with the grassland habitat type.

In addition to these major habitat categories, patches of scattered trees, such as box elder, and dense growths of various shrub species grow

along the intermittent drainages. These patches of trees and shrubs classified as riparian habitat, are concentrated along East Fork Armells Creek (see Figure 2.7-1). This riparian vegetation provides habitat for many species which otherwise may not occur in the area: white-tailed deer (Odocoileus virginianus), yellow warbler (Dendroica petechia), and eastern kingbird (Tyrannus tyrannus). The habitat is also used by mule deer, sharp-tailed grouse, and ring-necked pheasant.

Other areas of wildlife use include sandstone outcrops and stock ponds. Sandstone outcrops are scattered throughout the area and are generally less than 0.5 acre in size. In total, less than 20 acres are covered by sandstone outcrop, concentrated in areas C and B. Several stockponds and springs are also scattered throughout the mine area. These may be used as water sources for pronghorn, mule deer, and migrating waterfowl. They are generally less than 1 acre in size and may be dry for part of the year.

2.8.1 Big Game

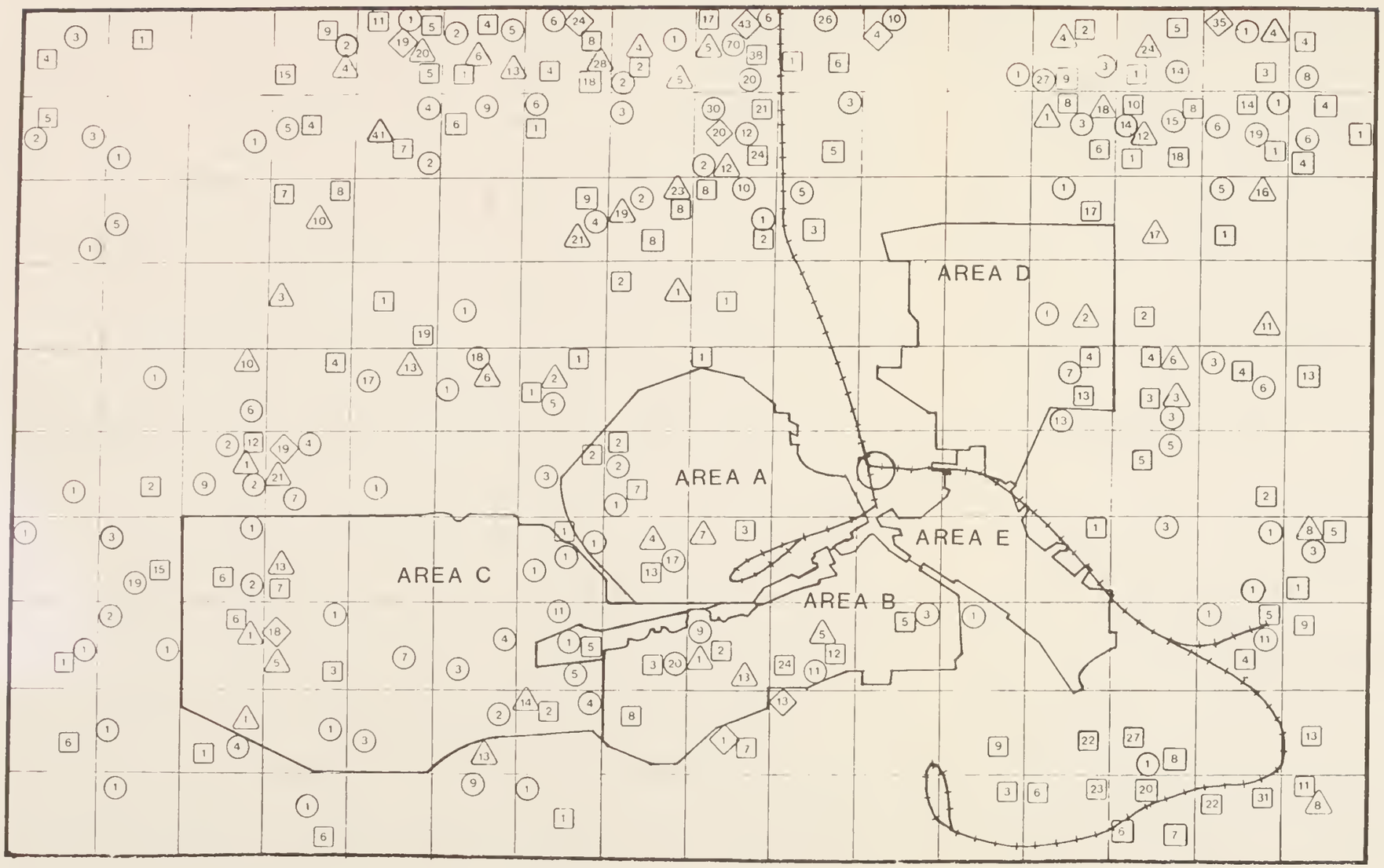
Most big game data are from aerial surveys conducted throughout the year. Although the surveys can indicate abundance, distribution, and herd composition, by sex and age class, quantification is seldom feasible.

Big game habitat preference data were also collected on the ground. Several difficulties were encountered: a lack of control over uniformity of coverage of the area, inability to define the relative level of sampling effort expended by habitat type, and the observability biases related to diurnal and seasonal activity patterns of the animals and accentuated difficulties with topographic and vegetation visibility barriers.

These considerations render the big game data unsuitable for rigorous statistical treatment or accurate quantification of population size and distribution. Therefore, the following big game descriptions emphasize indices of abundance and herd composition available from Western Energy's aerial surveys and rely heavily on published literature for general information on big game habitat requirements.

2.8.1.1 Pronghorn

The Colstrip area is commonly used by pronghorn antelope during spring, summer, and fall (Figure 2.8-1). During 1981, the animals used two habitat types (grassland and shrub-grassland) during 21 percent of the observations. Shrub and grassland habitat is particularly important to pronghorns during the winter months, when sagebrush may represent over three quarters of total forage intake. The relative scarcity of this habitat in the mine plan areas accounts for the reduced pronghorn population during winter. An occasional small herd may remain in the vicinity of Area C during mild winters. These wintering pronghorn range over suitable habitats in the upper East Fork Armells Creek, Upper Lee Coulee, and Stocker Creek drainages (Western Energy, 1980).



CUMULATIVE PRONGHORN ANTELOPE AERIAL SURVEY OBSERVATIONS 1978-1980

KEY

◇ Winter

□ Spring

○ Summer

△ Fall

99 Group Size

0 1 2 3

SCALE MILES

FIGURE 2.8-1

Productivity of the pronghorn herd in the study area, inferred from fawn/doe ratios, has been similar to estimates for production in game management units in the region. Fawn/doe ratios have been increasing since 1976 (Table 1, Appendix D). In the 1978 annual wildlife report (Ecological Consulting Service, 1979) observations of lone females, lone females with fawn, and lone fawns from mid-May to mid-June were concentrated in three areas: (1) the Corral Creek area, (2) the area paralleling the highway between Lower Corral Creek and Stocker Creek, and (3) Upper Cow Creek. Other suitable habitat for fawning is available within the mine plan area. Preferred fawning areas appear to be in open grasslands with depressions or swales.

2.8.1.2 Mule Deer

Mule deer are widely distributed over the Wildlife Study Area. Although deer forage in open grassland and agricultural fields, particularly in spring, they show a marked preference for conifer-shrubland and shrub-grassland habitat types during all seasons. These types are particularly important for forage and shelter during the harsh winter months, especially when snow cover restricts availability of low-growing forage. Moist creek/coulee bottom habitats are often favored by foraging deer in summer and fall. Although there is fairly consistent mule deer winter use of the eastern end of Greenleaf Ridge and West Fork Armells Creek, there generally are no large winter concentrations of deer observed in the Wildlife Study Area (Figure 2.8-2) (Western Energy, 1980). Because of their greater use of wooded and shrub habitats, deer typically are less visible; deer data tends to be somewhat less reliable and complete and not directly comparable to pronghorn data.

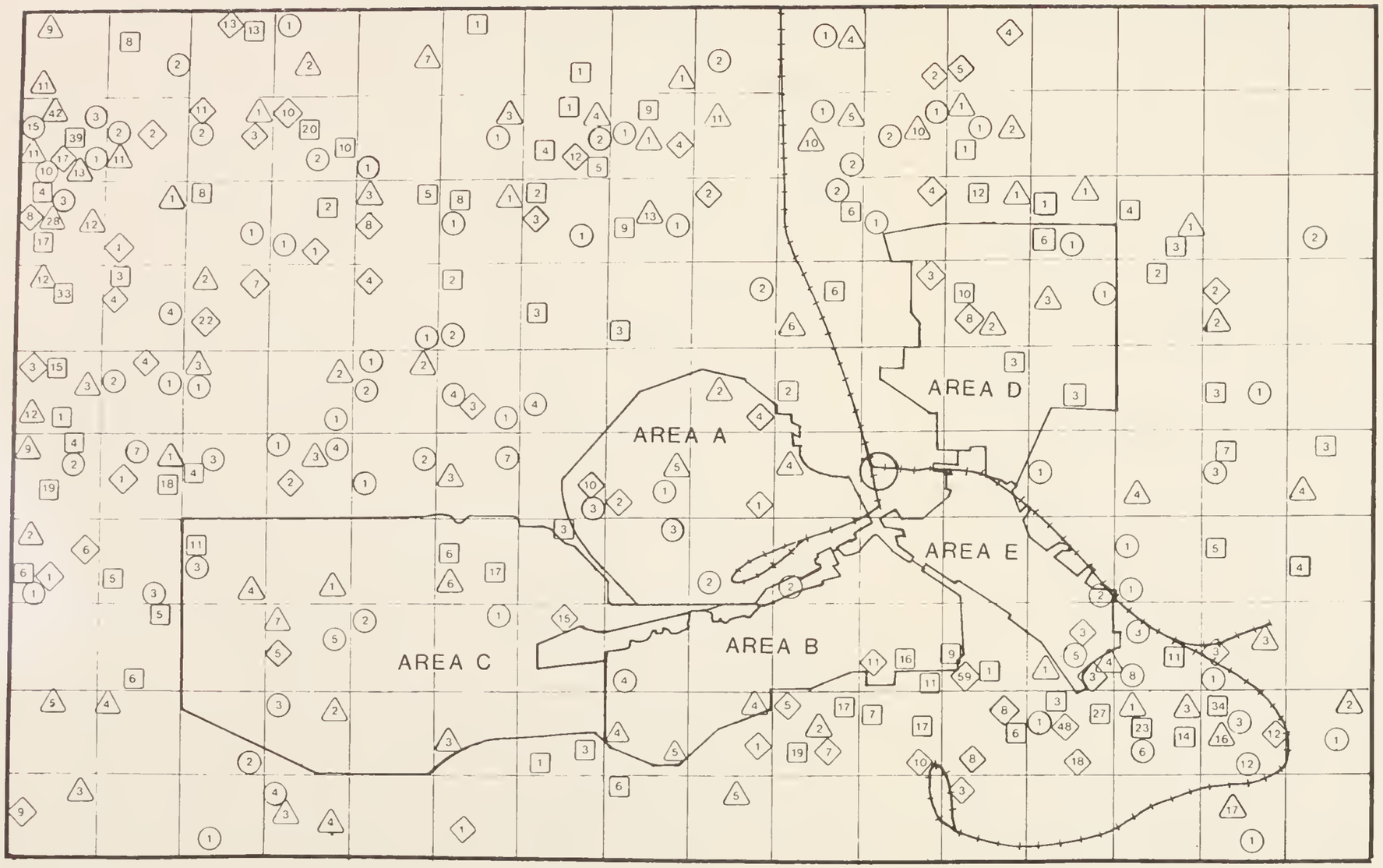
Mule deer fawn/doe ratios and observations per hour have fluctuated between highs and lows for the 8 years of study (Table 2, Appendix 1). However, in 1981 the productivity and observations increased substantially, indicating a recovery in the mule deer population. Numerous reasons could explain why few observations were recorded in the mid- to late 1970's, such as severe winter die-offs, legal and illegal hunting, and habitat insecurities due to increased development in the Colstrip area.

2.8.1.3 Other Big Game Animals

Other big game species reported in the study area have been white-tailed deer and elk (Cervus elaphus). Such observations are infrequent, since the area supports few white-tailed deer and no permanent elk population.

2.8.2 Other Mammals

Small mammals in the Colstrip area include bats, shrews, rabbits and hares, and numerous rodent species (see Table 3, Appendix D). Small mammals provide an important source of prey for mammalian predators and for raptors. A summary of small mammal trapping results from 1973 through 1978 can be found in Table 2.8-1.



CUMULATIVE MULE DEER
AERIAL SURVEY OBSERVATIONS
1978-1980

KEY

◇ Winter

□ Spring

○ Summer

△ Fall

99 Group Size

0 1 2 3
SCALE MILES

FIGURE 2.8-2

TABLE 2.8-1

Small Mammals Trapped in Colstrip Vicinity During the Period 1973 through 1978

Year	Client	Type of Trap	Habitat	No. Caught	No. of Species	No. of Trap-Nights	Catch/Trap Night		Species
Native Habitats:									
1973	MPC[1]	Snap	Native	91	3	500	0.182	89	Peromyscus maniculatus
								1	Microtus ochrogaster
								1	Sorex cinereus
1973	PBC[2]	Snap	Native	72	2	700	0.103	70	Peromyscus maniculatus
								2	Microtus ochrogaster
1974	PBC	Snap	Native	94	1	600	0.157	94	Peromyscus maniculatus
1974	WEC[3]	Snap	Native	60	2	400	0.150	56	Peromyscus maniculatus
								4	Microtus ochrogaster
1976	PBC	Snap	Native	9	3	300	0.030	6	Peromyscus maniculatus
								2	Microtus ochrogaster
								1	Spermophilus tridecimlineatus
1976	PBC	Live	Native	2	1	100	0.020	2	Peromyscus maniculatus
1977	PBC	Snap	Native	10	2	400	0.025	9	Peromyscus maniculatus
								1	Microtus ochrogaster
1978	WEC	Snap	Native	40	1	600	0.067	40	Peromyscus maniculatus
							$\bar{x}$ = 0.092		
Reclamation:									
1973	MPC	Snap	Reclamation	30	1	50	0.600	30	Peromyscus maniculatus
1974	PBC	Snap	Reclamation	19	1	100	0.190	19	Peromyscus maniculatus
1975	MPC	Live	Reclamation	28	3	200	0.140	25	Peromyscus maniculatus
								1	Reithrodontomys megalotis
								2	Microtus ochrogaster

(continued)

TABLE 2.8-1

Small Mammals Trapped in Colstrip Vicinity During the Period 1973 through 1978--Continued

Year	Client	Type of Trap	Habitat	No. Caught	No. of Species	No. of Trap-Nights	Catch/Trap Night		Species
Reclamation (continued):									
1976	PBC	Live	Reclamation	36	3	100	0.360	34	Peromyscus maniculatus
								1	Microtus ochrogaster
								1	Spermophilus tridecimlineatus
1977	PBC	Live	Reclamation	7	1	200	0.035	7	Peromyscus maniculatus
1978	WEC	Live	Reclamation	55	3	200	0.275	46	Peromyscus maniculatus
							$\bar{x}$ = 0.267	8	Reithrodontomys megalotis
								1	Microtus ochrogaster

[1]MPC = Montana Power Company

[2]PBC = Peabody Coal Company

[3]WEC = Western Energy Company

The black-tailed prairie dog is a species of concern in Montana (Flath, 1981). One prairie dog town is located just north of Area A. This town covers approximately 100 acres south of Stocker Creek. Prairie dog towns can provide habitat for an endangered species, the black-footed ferret (Mustela nigripes). (See Threatened and Endangered Species, Section 2.8.10).

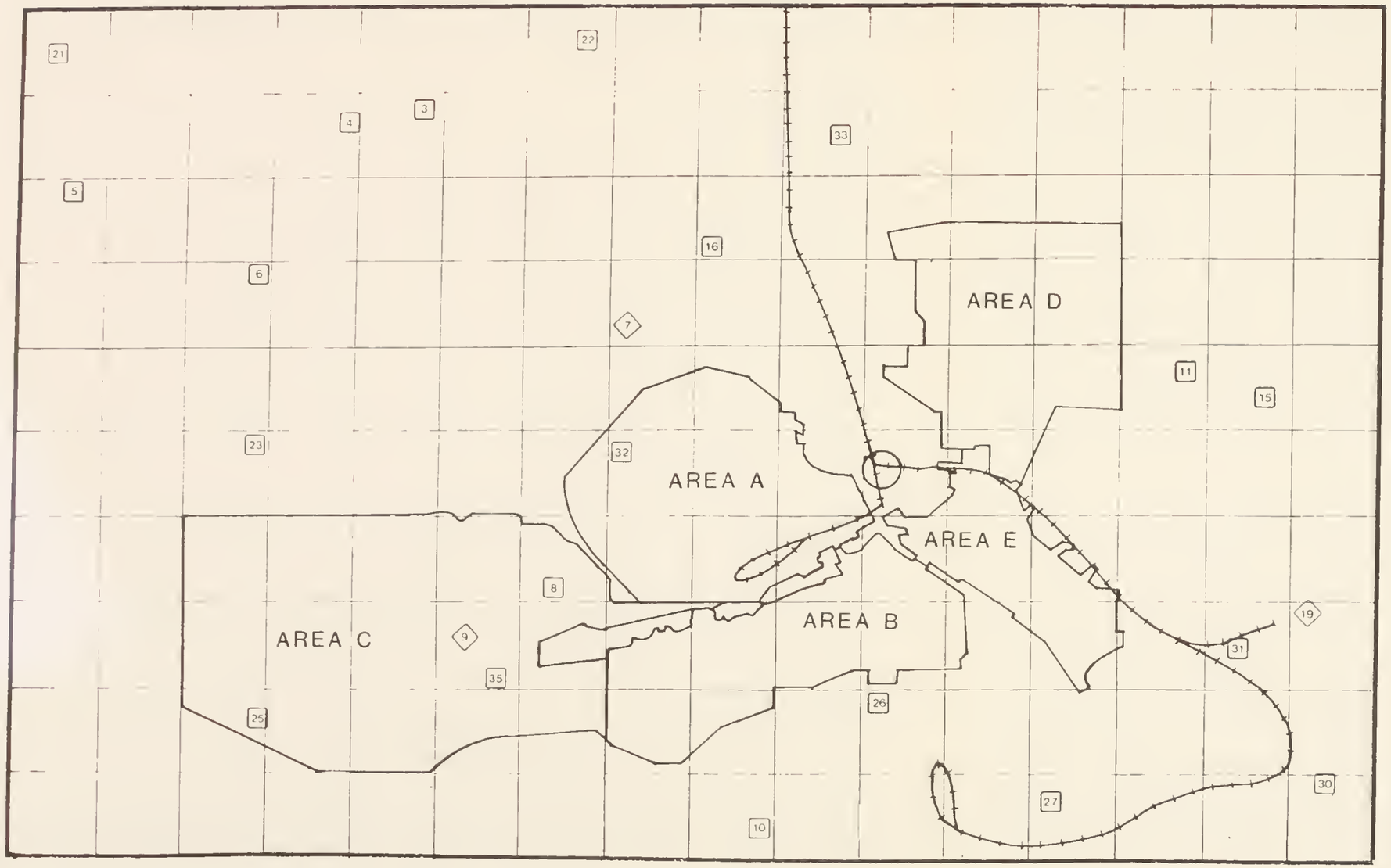
Other mammals that have been observed in the area include porcupines (Erethizon doarsatum) and chipmunks (Eutamius minimus), which inhabit conifer-shrubland habitat; cottontails (Sylvalagus spp.) and marmots (Marmota flaviventris), in rocky areas; and muskrats (Ondontra zibthicus), found in stock ponds and Castle Rock Reservoir. No population estimates have been made for these species.

2.8.3 Mammalian Predators

The most common large mammalian predator in the Colstrip area is the coyote. Other predators, seen infrequently, include the badger (Taxidea taxus), red fox (Vulpes vulpes), and bobcat (Western Energy, 1980). Habitats found in mine plan areas could be used by all these large predators. Coyotes are widely distributed throughout the area. Red foxes range across open brushland, woodlands, and farmlands and are often associated with disturbed areas. Bobcats prefer rugged forested and shrubby areas (Whitaker, 1980), like those found in the north-central part of Area C, the northern part of Area A, much of Area D, and on Greenleaf Ridge south of Area B. Mammalian predators known in the area are shown in Table 3, Appendix D.

2.8.4 Upland Game Birds

The sharp-tailed grouse is the most abundant native upland game bird in the Colstrip vicinity. Sharp-tail dancing grounds are fairly evenly distributed across the Wildlife Study Area (Figure 2.8-3) with 20 active dancing grounds in the area in 1980 (Western Energy, 1980). Eight years of sharp-tail investigations in the Colstrip vicinity have shown consistent numbers of grouse in the area, with variable attendance at individual dancing grounds (Table 2.8-2). During the years of study, some grounds were abandoned, while new grounds were apparently established (Ecological Consulting Service, 1975, 1976). The Area C vicinity has four dancing grounds; Area A has one; Areas B, D, and E have none. However, there are dancing grounds close to B, D, and E. Dancing grounds tend to be in open, sparsely grassy areas, often on knolls or ridges (Hillman and Jackson, 1973). Nesting habitat is generally ungrazed shrub-grassland or lightly grazed grassland with good ground cover. Radio-telemetry studies in the Colstrip area have indicated that nesting has occurred as far as 2 miles from the dancing grounds. Upland habitat types are preferred by sharp-tailed grouse. Moderately dense grass or grass-shrub cover provides shade and protection from detection by predators. Small-grain fields, like those found in Area C and to a lesser extent in Area D, are an important supplementary food source.



APPROXIMATE LOCATIONS OF SHARP-TAILED GROUSE DANCING GROUNDS

KEY

99 Site Number

☐ Active Arena

◇ Inactive in 1980

0 1 2 3

SCALE MILES

FIGURE 2.8-3

TABLE 2.8-2

Maximum Number of Male Sharp-tailed Grouse Attending Dancing Grounds on the Western Energy Company Study Area During the Springs of 1973 through 1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	13	8	10	13	5	9	9	11	5
3	17	21	27	22	26	21	14	8	0
4	18	14	10	17	17	13	18	23	13
5	13	18	16	15	17	19	17	22	7
6	9	9	13	6	4	9	9	6	2
7	13	13	20	11	0	0	0	0	0
8	14	15	11	8	2	5	13	20	10
9	12	4	0	0	0	0	0	0	0
10	8	2	3	0	5	13	9	3	3
11	14	13	15	10	11	13	12	6	2
15	--	10	15	7	10	13	10	10	8
16	--	8	15	6	6	9	9	12	7
19	--	12	17	14	6	0	0	0	0
20	--	12	16	12	14	20	21	17	13
21	--	--	22	17	20	21	18	20	11
22	--	--	15	10	14	18	18	25	12
23	--	--	10	15	13	18	11	14	6
25	--	--	16	13	17	7	15	19	15
26	--	--	--	4	2	0	0	2	1
27	--	--	--	--	17	21	15	20	14
30	--	--	--	--	--	33	31	14	8
31	--	--	--	--	--	22	18	23	12
32	--	--	--	--	--	9	11	4	0
33	--	--	--	--	--	--	18	14	*
34	--	--	--	--	--	--	3	17	9
35	--	--	--	--	--	--	--	8	6
36	--	--	--	--	--	--	--	--	9
Totals	131	159	251	200	199	263	299	318	171
Average Number of Males per Active Dancing Ground	13.1	11.4	14.8	11.8	11.1	15.4	14.2	13.8	8.1
Estimated Sharp-tail Density (#/mi²)[1]	2.5	3.0	4.7	3.8	3.7	5.5	5.6	6.0	3.2

*not counted

[1] $\frac{\text{Total number of males} \times 3}{\text{(see Rippin and Boag, 1974; Hamerstrom, personal commun., 1979)}}$
$\text{160 square miles (size of study area)}$

Ring-necked pheasant crowing counts have been conducted since 1975 in the Wildlife Study Area. The main concentration area for pheasants is in the East Fork Armells Creek drainage, primarily in the rail loop track in Area A. Overall, the study area is marginal pheasant habitat as reflected by low call-count results. Barley and wheat plantings and a winter feeding program enhance pheasant survival and production in the vicinity of the rail loop track (Western Energy, 1980).

Fewer Hungarian (Gray) partridge (Perdix perdix) and Merriam's turkey are found in the Wildlife Study Area. The Hungarian partridge is most often observed in reclaimed areas with good grass cover; turkeys are most often observed in grassland, shrub-grassland, and conifer-shrubland areas, typically in the portions of the study area with rougher topography, especially Area D.

Sage grouse (Centrocercus urophasianus) are not abundant in the Wildlife Study Area and have not been observed in any of the mine areas, except Area B, in recent years.

2.8.5 Waterfowl

The number of waterfowl seen and recorded in southeastern Montana, including the Wildlife Study Area, are included in Table 4, Appendix D. Several of these waterfowl are considered of high Federal interest (Spear, 1980). Of these species, only the canvasback (Aythya valisineria) has been reported in the study area (Ecological Consulting Service, 1979). Most waterfowl observations are associated with Castle Rock Reservoir, the Area A sediment pond, East Fork Armells Creek, and several small stock impoundments. Several mallard (Anas platyrhynchos) nests have been located in the Area A and Pit 6 reclamation areas. Mallards, northern shovellers (Spatula clypeata), and blue-winged teal (Anas discors) broods have been observed on the Area A sediment pond.

2.8.6 Songbirds

The Migratory Bird Act of 1973 (16 USC 703-711) placed most songbirds in the United States under Federal protection. Table 4, Appendix H, lists songbirds probably in the Colstrip area on the basis of published reports, and notes those observed as part of the Wildlife Study Area investigations (Ecological Consulting Service, 1973, 1974, 1975; ECON, 1976, 1977, 1978, 1979; Western Energy, 1980). Most of the observed songbirds have been species commonly associated with grassland, shrub-grassland or with open pine forests, all found throughout the area (see Table 2.8-3). None of the songbird species observed in the study area are listed as threatened or endangered. No songbird species of Federal interest (Spear, 1980) have been recorded in the Wildlife Study Area, although the area is within the range of and is suitable habitat for several. State species of special concern that have been observed in the area include eastern bluebird (Sialia sialia) and western bluebird (Sialia mexicana).

TABLE 2.8-3

Songbird Breeding Densities for Four Habitat Types on the Western Energy Company Study Area, 1981

Species	Upland Grassland	Big Sagebrush-Grassland	Timber-Grassland	Reclamation
American kestrel		*	**	
Killdeer	16[a]			
Mourning dove	**	**	**	**
Common flicker		*	16	
Red-headed woodpecker			16	
Eastern kingbird		16		
Western kingbird		8		
Black-capped chicadee			64	
White-breasted nuthatch			16	
Red-breasted nuthatch		*	24	
House wren			80	
Rock wren		*	16	
American robin			48	
Mountain bluebird		16	16	
Solitary vireo			48	
Yellow warbler		8		
Audubon's warbler			32	
Western meadowlark	112	24		96
Brewer's blackbird		16	*	
Brown-headed cowbird			*	
Pine siskin			16	
Red crossbill			*	
Roufous-sided towhee		*	48	
Lark bunting		*		
Vesper sparrow	32	16		32
Lark sparrow	*	48	16	
Chipping sparrow		16	80	
Clay-colored sparrow		8		
Brewer's sparrow		48		

[a] no. per square mile

* observed, not suspected of breeding

** suspected breeding

2.8.7 Raptors

The most common raptors in the Colstrip area are the red-tailed hawk (Buteo jamaicensis), American kestrel (Falco sparverius), and marsh hawk (Circus cyaneus) (Bricco, 1981; ECON, 1979). Other common raptors are the great horned owl (Bubo virginianus), prairie falcon (Falco mexicanus), and golden eagle (Martin, 1981; ECON, 1979; Western Energy, 1980). Table 4, Appendix D, includes raptors expected to occur or raptors actually observed in the study area.

Although all raptor species are federally protected, several seen in the Wildlife Study Area have been given special status by Montana (Flath, 1981) or the Federal Government (Spear, 1980). These species are discussed briefly in the following paragraphs.

Golden eagles and bald eagles (Haliaeetus leucocephalus) are protected by the Bald Eagle Protection Act of 1940, as amended in 1962 (16 U.S.C. 668). Golden eagles are observed often in the Colstrip area, and have nested on a sandstone cliff in Area C as recently as 1978 (Ecological Consulting Service, 1978, 1979). In all, four golden eagle nest sites, two on sandstone cliffs and two in ponderosa pine trees, have been identified in the Colstrip area. One cliff nest and one tree nest were located south of the mine plan area on the mine areas of Peabody Coal Company. Rabbits and rodents are usually the primary food of golden eagles (Peterson, 1961).

The ferruginous hawk (Buteo regalis) was observed in the northern part of Area C during a 1978 bird survey (Ecological Consulting Service, 1978), and is listed as a species of high Federal interest (Spear, 1980). Ferruginous hawks may nest in trees, on cliffs, or on the ground in open rangeland and have been known to feed on prairie dogs and ground squirrels (Udvardy, 1977).

Prairie falcons (Falco mexicanus), considered of high Federal interest (Spear, 1980), are common in the Colstrip area: three active nests were recorded in the study area in 1980 (Western Energy, 1980). The birds nest on cliff ledges and eat rodents and songbirds in open country (Udvardy, 1977). Prairie falcon nests are located on the same sandstone outcrop in Area C as the golden eagle nest, on Eagle Rock just outside the northern boundary of Area D, and in the Pit 6 area. These falcons are of special interest in the Colstrip area because of the number of known nests and occupied territories.

The burrowing owl (Speotyto cunicularia) was observed in the southwest corner of Area C in 1979 (ECON, 1979), is of high Federal interest (Spear, 1980), and is thought to be declining in Montana (Bricco, 1981). This owl lives in burrows deserted by species such as prairie dogs or badgers (Taxidea taxus) and hunts rodents and insects, mostly by day. Grasslands and shrublands throughout the study area could provide suitable habitat for the burrowing owl.

Several species of raptors observed during Rosebud Mine Wildlife Resource Studies are listed as species of special concern in Montana (Flath, 1981). These species are Cooper's hawk (Accipiter cooperii),

ferruginous hawk, golden eagle, bald eagle, prairie falcon, merlin (Falco columbarius), burrowing owl, and long-eared owl (Asio otus).

Other raptor nests found in the study area as of 1980 include four great horned owl (Bubo virginianus) nests, five red-tailed hawk nests, and five American kestrel nests, none of which actually occur on the area to be mined. A marsh hawk nest was located in Pit 6 during 1982.

2.8.8 Reptiles and Amphibians

No specific surveys have been conducted for reptiles or amphibians, but incidental sightings have been noted in the annual wildlife surveys at the Rosebud Mine (Western Energy, 1980). Prairie rattlesnake (Crotalus viridis) sightings were mentioned every year from 1976 through 1980. Bull snake (Pituophs melanoleucus) sightings were mentioned each year from 1977 through 1980. Other reptiles and amphibians mentioned in the annual wildlife survey reports include the snapping turtle (Chelydra serpentina), painted turtle (Chrysemys picta), sagebrush lizard (Sceloporus graciosus), hognose snake (Heterodon sp.), racer (Coluber constrictor), salamanders (Ambystoma sp.), and frogs.

Table 5, Appendix D lists reptiles and amphibians expected to occur in southeastern Montana (Stebbins, 1966), and notes observations in the Rosebud Wildlife Study Area between 1976 and 1980 (Ecological Consulting Service, 1976a, 1977a, 1978, 1979; Western Energy, 1980). Turtles, salamanders, and frogs are not likely to be common in any of the mine areas since they require a wet habitat. Area C, along East Fork Armells Creek, and Area A, at the sediment pond and anywhere a spring or stock tank provides surface water, may support a small number of water-associated species. Hognose snakes, of special concern in Montana (Flath, 1981), may be present, especially in farmland. Prairie rattlesnakes inhabit virtually all of the terrestrial habitat types present in the study area (Stebbins, 1966; ECON, 1981).

2.8.9 Fish

The ephemeral creeks at the Rosebud Mine are of minimal value as a fishery resource. At certain times of the year, common nongame fish such as the flathead chub (Hybobsis gracillis), lake chub (Cauesius plumbeus), white sucker (Catastomus commersoni), stonecat, (Noturus falvus), and fathead minnows (Pimephales promelas) may drift down from the Yellowstone River, but none of these creeks is currently classified as a sport fishery by the Montana Department of Fish and Game.

Castle Rock Lake, the Colstrip surge pond, has been stocked with such sport species as northern pike (Esox lucius) black crappies (Pomixis nigromaculatus), white crappies (P. annularis) and largemouth bass (Micropterus salmoides).

Regional fishery resources are discussed in Section 2.12.

2.8.10 Threatened and Endangered Species

Bald eagles (Ecological Consulting Service, 1979) and a peregrine falcon (Martin, 1981) have been observed in the Wildlife Study Area during migration. These two birds are listed as endangered species; however, no critical habitat for either bird is known to be present in the Colstrip area. No specific studies for these species were conducted.

Because the endangered black-footed ferret is largely dependent on prairie dogs for food, the possibility of black-footed ferrets being present must be considered. There are no records of black-footed ferrets in Rosebud County. The only known prairie dog colony, approximately 100 acres in size, is north of Area A in the Stocker Creek drainage. In 1978 and 1979 the colony was inspected for black-footed ferret signs. Additionally, a black-footed ferret spotlight survey was conducted in 1979. None of these surveys revealed evidence of black-footed ferrets (Ecological Consulting Service, 1978, 1979). However, there have been recent discoveries of ferrets in Wyoming and research on them is continuing. New techniques developed from the ongoing research could reveal previously undetected black-footed ferret use.

2.9 SOCIOLOGY AND ECOMONICS

2.9.1 Economic/Demographic Conditions

2.9.1.1 Economic Conditions

Traditionally, agriculture has been the primary economic activity in Rosebud County. But during the past decade, agriculture has been declining in importance. The county is undergoing a transition from an agrarian economy to an economy primarily dependent on energy development: personal income and employment for energy-related activities has substantially increased, and agricultural income and employment has decreased. All statistical data presented in the following sections was derived from the Bureau of Economic Analysis, U.S. Department of Commerce.

2.9.1.1 1 Personal Income

Over the past decade, labor income has been the most significant contributor to total personal income in Rosebud County, more so than in the State of Montana as a whole. Labor and proprietors' income (sometimes called participation income) accounted for about 84 percent of total personal income during 1979 in Rosebud County and approximately 73 percent in Montana. In 1970, the corresponding figure was about 79 percent for Rosebud County and 78 percent statewide.

Table 1 (Appendix E) presents personal income by major source for Rosebud County and Montana during 1970 and 1979. Annual data for Rosebud County are shown in Table 2 (Appendix E). These figures were converted to constant 1980 dollars.

In 1979, agriculture accounted for only 2.7 percent of total personal income, compared to 18.7 percent in 1970. Since 1970, mining and construction have shown sizeable gains. In particular, mining increased from 3.9 percent of total personal income in 1970 to 20.9 percent in 1979. Despite the downward trend, the relative importance of agriculture in Rosebud County continues to be slightly greater than the figure for Montana. However, the relative importance of mining employment in Rosebud County is more than four times the figure for Montana.

Per capita income figures for Rosebud County and Montana from 1970 to 1979 are presented in Table 3 (Appendix E). Per capita income is equal to total personal income divided by population; in other words, it is average income per person. To correct for inflation per capita income was converted to constant 1980 dollars.

Per capita income in 1979 for Rosebud County was $6,948 (1980 dollars), or about 19 percent below the Montana average of $8,601 (1980 dollars). During the 1970's, real per capita income in Rosebud County grew at about the same rate as in Montana: between 1971 and 1979 it rose 26.5 percent in Rosebud County and 26.4 percent statewide. The stability of real wages in the country from 1970 to 1979 indicates that Colstrip Units 1 and 2 did not significantly increase labor costs to local businesses

(Polzin, 1981). Per capita income in Rosebud County was much more variable than in Montana during the 1970's, reflecting the wages paid during the construction of Colstrip Units 1 and 2, and the fact that agricultural income is highly cyclical.

2.9.1.1.2 Employment

As shown in Table 4 (Appendix E), total employment in Rosebud County rose from 2,465 in 1970 to 4,472 in 1979, an increase of about 81.4 percent. Annual data for Rosebud County are presented in Table 5 (Appendix E). In Montana, total employment increased from 279,091 to 373,409, or 33.8 percent, during the same period.

The decline of agriculture and manufacturing, and the rise of mining, services, construction, government, transportation, and public utilities employment is evident, as shown in Table 4 (Appendix E). In 1970, agriculture was the largest employer; by 1979, both services and government employed more people.

In addition to a breakdown by kind of work (e.g. agriculture, mining, etc.), the labor market may be divided into basic and derivative industries. Basic industries depend on nonlocal markets or are influenced by factors from outside the area. Derivative industries, on the other hand, serve the local population. Economists believe that changes in basic industries lead to further changes in derivative industries. Employment data for Rosebud County have been organized into basic and derivative categories, presented in Table 6 (Appendix E). The decreasing importance of agriculture and the increasing importance of mining, construction, transportation, and public utilities to the economic base of Rosebud County is reemphasized by this data.

2.9.1.1.3 Retail Trade

Sparsely populated rural counties tend to support only one small community, where most of the trade and service activity is generated. In many cases, practically all the nonfarm population lives in this community. Multicounty areas will generate enough retail trade activity to support a small retail trade center. Northern and eastern Montana, outside the influence of Great Falls and Billings, supports three small retail trade centers: Havre and Miles City, Montana, and Dickinson, North Dakota (Upper Midwest Council, 1982).

The movement of a large number of new residents into a previously stable, rural area can alter trade patterns, and this may in turn affect settlement patterns. For example, the extent to which Colstrip grows will be principally affected by future trade development in southern Rosebud County and secondarily affected by the provision of local amenities, such as shopping and entertainment.

The purpose of this section is (1) to assess retail trade within and with Rosebud County, and (2) to estimate the potential for Colstrip to grow

as a trade center and therefore attract more residents. Our approach is to rely on interviews with informants in Forsyth and Colstrip and a January 1982 Colstrip Area Market Study (Mountain West Research, 1982). In addition, we have reviewed the 1977 Census of Retail Trade and a study entitled "Upper Midwest Retail Trade Centers" (Upper Midwest Council, 1982).

Two major types of retail goods demonstrate consumer response: "comparison" goods (general merchandise, apparel and accessories, and furniture, home furnishings, and equipment) and "convenience" goods, such as food, gasoline, drugstore items, and hardware. For comparison goods, customers shop extensively and are willing to travel long distances for lower prices and wider choice. These goods, more than others, may attract shoppers from outside the county. Convenience goods, on the other hand, are generally purchased near home, with little travel. Variables influencing all retail sales include population, personal income, spending patterns, and proximity of competing trade centers.

Billings has been classified as a large retail trade center and Miles City as a small center (Upper Midwest Council, 1982). Seventy-two percent of surveyed Colstrip households indicated they shopped for comparison goods in Billings. Table 7 (Appendix E) indicates that in Yellowstone County the ratio of retail sales to income is 20 percent greater than the State average, indicating that many sales are to surrounding counties.

Custer County, containing Miles City, has a large net outflow of county-generated comparison sales, and a net inflow of convenience sales (Upper Midwest Council, 1982). This is supported by Table 8 (Appendix E), which shows that the ratio of gasoline, eating and drinking, and grocery sales to personal income in Custer County is greater than for the State as a whole. Although Custer County, as a retail trade center has been declining, retail trade performance is still strong compared to other local rural counties (see Table 8, Appendix E).

Because Rosebud County is near both Miles City and Billings, it has fared poorly in retail trade, particularly in comparison goods. Table 7 (Appendix E) indicates that in 1977 the county had the lowest capture rate of sales as a percentage of income of the seven rural counties listed.

Table 8 (Appendix E) shows that it was also at or near bottom for the two convenience goods categories shown: gasoline, eating and drinking. This probably will not change, given Billing's strength and the projections for growth in both Billings and Miles City. Therefore, retail sales in Colstrip and Forsyth will largely depend on the availability of convenience goods.

Today, Forsyth is the center for trade and services in Rosebud County. All comparison goods shopping done in Rosebud County, except for farm implements, takes place in Forsyth. Most eating, drinking, and entertainment consumption taking place in the county is also in Forsyth. Ten percent of the household survey respondents indicated that they shopped for comparison goods in Forsyth; 9 percent mentioned Miles City.

Many Forsyth merchants own their stores, and those that rent pay $1 to $3 per square foot for downtown space (Thiessen, 1982). Colstrip probably

cannot generate competitive comparison goods shopping, given the higher rental and transportation costs.

Colstrip is relatively underdeveloped commercially. Reportedly, this is due to a number of factors: the lack of commercial space, high rents coupled with high interest rates, Sunlight Development Company's strict controls over development, and difficulties in obtaining financing from previous management at the local commercial bank (Knudsen, Rugemer, 1982). The mall is apparently having no trouble in keeping its space occupied, even though its rates are about $9 per square foot. Almost 80 percent of the mall space is occupied by the U.S. Post Office, Security Bank, health clinics, and a hardware-pharmacy store. As shown in Table 9 (Appendix E), practically all the retail outlets in Colstrip are for convenience goods.

Many residents feel Colstrip needs additional retail businesses. In the January 1982 household survey, 29 percent of the respondents felt a family restaurant was needed; 13 percent, a gasoline service station and variety store; and 9 percent, a clothing store and bowling alley. Local informants indicated that a family restaurant, grocery store, clothing store, movies, and more entertainment outlets could be supported (Thiessen, Rugemer, 1982).

The Colstrip Area Market Study also suggested that all these types of retail establishments would be "needed" by 1985, although the clothing store was denoted as being "marginally viable." The Market Study used a threshold analysis complemented by interviews with local business people. The threshold analysis used the 1977 Census of Retail Trade to determine the number of people in rural Montana necessary to support a certain type of retail establishment. These numbers were then compared with the projected 1985 population of the Colstrip Trade Area (9,900 to 10,700) to derive a list of potentially supportable commercial establishments. This list was modified through discussions with local business people. Potential comparison goods outlets were dropped from the list for reasons similar to those reasons cited above (Mountain West Research, 1982).

Table 10 (Appendix E) shows the retail establishments potentially needed in 1985. It is unclear to what extent the costs of business in Colstrip and the competitive position of Forsyth influenced this list, but the poor past performance of Rosebud County in convenience goods sales indicates that the list is reasonable. Assuming the population projections are accurate and financing and overhead costs are reasonable, counties should be able to reach nearly their full potential of convenience goods sales (Upper Midwest Council, 1982).

Plans for the shopping center include many stores that Colstrip may be able to support, such as a grocery, supper club/lounge, twin theatre, bowling alley, drug or variety store, hardware store, pizza/ice cream shop, and a 32-room motel. The project principals recently submitted to the Rosebud County Commissioners a proposal for the county to issue Industrial Revenue Bonds to finance the $6,000,000 center, but the commissioners rejected the plan. Today, project backers remain confident that a strong market exists for the center, but financing uncertainties continue to cloud the project's viability. The major uncertainty is the cost of financing.

Other important considerations are price and construction period. In addition, project scale and tenant mix are continually being reevaluated (Potter, 1982).

2.9.1.2 Demographic Conditions

The 1970 and 1980 populations of Colstrip, Forsyth, Rosebud County, and Montana are presented in Table 11 (Appendix E). Additional data are presented in Table 12. Estimates for Colstrip and Rosebud County have been used rather than census figures to more accurately present growth in the area. The timing of the census and the boundaries of some census districts distorted the count of area residents. Population estimates were developed by Western Analysis, Inc. (1982), based on actual employment and population/employment multipliers.

The populations of Colstrip and Rosebud County increased dramatically during the 1970's, while the increase in Forsyth was not as large. Colstrip's 1980 population increased thirteenfold. The Rosebud County population nearly doubled. Forsyth's population increased by more than a third. By comparison, the population of Montana increased 13 percent (U.S. Bureau of the Census, 1981). In 1980, 21.5 percent (702 people) of Colstrip's population and 9.8 percent (1,114 people) of Rosebud County's population were attributable to employment at the Rosebud Mine. The percentages represent workers, their families, and derived employment. The Rosebud County population contains a large proportion of nonwhite persons, due to the presence of the Northern Cheyenne Indian Reservation. The Indian proportion of the county population declined between 1970 and 1980, due to the large number of white immigrants.

A comparison of the age and sex compositions of the 1970 and 1980 Colstrip, Forsyth, and Rosebud County populations is shown in Table 13 (Appendix E). A comparison of age groups expressed as a percentage of total population is presented in Table 14 (Appendix E) for Colstrip, Forsyth, and Rosebud County populations. All three populations have shifted toward younger adult age groups (20 to 44), with decreases in the proportions of older adults. This is more pronounced in the Colstrip and Forsyth populations, where the age 25 to 34 group proportion has doubled or nearly doubled during the decade. Slight increases in the proportion of younger children (ages up to 9) also occurred in the Colstrip and Forsyth populations. The sex ratios of all three areas' populations show a slight surplus of males in 1970. In 1980, the surplus of males in Colstrip had increased 10 percent; a much smaller increase occurred in the Rosebud County population. Forsyth experienced a 10 percent decrease in the male/female ratio during this period, resulting in a population about 49 percent male in 1980 compared to 52 percent in 1970.

Data on the Ashland-Birney-Northern Cheyenne Reservation area are presented in Table 15 (Appendix E). The population of the area continued 20 years of growth, in both Northern Cheyenne and white populations. The Cheyenne proportion has declined in the past two decades. Likewise, aged persons make up a small and declining proportion.

Data on county and state population marital status are presented in Table 16 (Appendix E). Slightly smaller proportions of the county population are single, married, or widowed than of the State population. This results in part from the larger proportion of younger persons in the county than in the State. Differences in the marital statistics between the county and the State are consistently minor.

On the Northern Cheyenne Reservation, the 1980 population was 3,255 persons, or 5 people per square mile. Natural increase will expand the population 1.1 percent annually, resulting in a 2010 population of over 5,200 people, nearly 60 percent larger than in 1980. The largest towns on the reservation are Lame Deer (Rosebud County) and Busby (Big Horn County).

2.9.1.3 Baseline Economic/Demographic Forecast

Table 17 (Appendix E) contains the annual employment and population forecast for Rosebud County. Table 18 (Appendix E) presents personal income projections for the county.

The baseline scenario for the Comprehensive Study includes all projects in the impact scenario of the Area C EIS: the operations of Western Energy, Long Construction, and Peabody Coal Company, the continued construction of Colstrip Units 3 and 4, the operations of Units 1 through 4, Colstrip townsite expansion.

As displayed in Table 18 (Appendix E), per capita income in Rosebud County is projected to increase during the construction of Area C and Colstrip Units 3 and 4. Afterwards, by 1985, per capita income would return to normal levels. In dollars, per capita income would increase from $7,986 (1980 dollars) in 1980 to $9,290 in 1983, then to decrease to $8,529 by 1985. Beyond 1985, real per capita income is projected to grow through 2010 to $17,441.

Total employment and population for Rosebud County, Colstrip, and Forsyth, are expected to peak in 1983, decline through 1990, and then gradually increase through 2010. Employment for 1983 in Rosebud County is 8,168 persons; population is 16,419 persons. County employment is projected to decline 28 percent through 1990, to 5,890, and then increase 12 percent through 2010, to 6,590. Nonbasic employment is forecast to increase by 51 percent through 2010, an increase of 1,053 jobs. In 1983, Colstrip population is expected to peak at 7,259 and the Forsyth population at 2,840. The Colstrip population is forcast to decline to 3,853 by 2010, while Forsyth's population will decline slightly and then rise to 2,823 by the same year.

In 1980 about 519 of the jobs in Rosebud County were due to the Rosebud Mine. About 320 of the jobs were in mining and as support staff; the remaining 198 jobs were in the nonbasic (derivative) sector.

The percentage of Colstrip's and Rosebud County's population attributable solely to the Rosebud Mine is projected to be lowest at the peak of Units' 3 and 4 construction (1982). The Rosebud Mine would then be respon-

sible for 13.3 percent of Colstrip's population and 8.8 percent of Rosebud County's population. By 1985 the percentages would climb to their highest level--over 30 percent for Colstrip and 15 percent for Rosebud County--and would remain relatively stable through 2010.

Between 1980 and 1985, basic employment, total employment, and population follow the construction cycle of Colstrip Units 3 and 4. Completion and start up are expected in fall 1983 for Unit 3 and fall 1984 for Unit 4 (Kelley, 1982). Between 1990 and 2010, basic employment, total employment, and population in Colstrip, Forsyth and Rosebud County are forecast to increase due to growth in the trade, services, and nonfarm proprietors industries. The service industry, in particular, grew significantly after the completion of Colstrip Units 1 and 2 and is expected to continue to expand through 2010.

The recent addition to the Rosebud Mine (Area C) is expected to increase total employment in the county by about 381 jobs, 228 at the mine and 153 in the nonbasic sector. More than 90 percent of the increase is expected by 1985; the remaining increase would occur between the years 2000 and 2010, during an increase in employment at Area C. After 1985, total county employment due to the mine would remain nearly constant, fluctuating between 908 and 922 jobs, about 15 percent of projected baseline employment. Between the years 2000 and 2010, total employment would increase slightly, to about 962 jobs, but the percentage would remain at about 15 percent.

The reader should note that in this analysis, temporary construction employment for Area C was assumed to have no effect on other employment in Rosebud County. That is, the existing work force in trade and services was assumed to absorb the temporary impact. Mining employment, on the other hand, was assumed to have an effect on support sector employment. Retail and service employers in the area were assumed to regard mining employment as long term and to expand or build new facilities to accommodate the enlarged economic base.

Population impacts from the temporary heavy construction work force in Area C were also assumed to be different from those for the permanent mining work force. The projected Area C work forces were residency adjusted before the population impacts were computed to account for out-of-Rosebud County and out-of-Colstrip commuting. It was assumed that 30 percent of the construction work force and 37 percent of the mining work force would commute to Colstrip. Ten percent of the mining work force and 15 percent of the construction work force were assumed to commute into Rosebud County (Edwards, Reardon, Spiegel, Tomasik, 1982).

Despite the decrease projected in agricultural employment, agriculture will continue in Rosebud County as a large employment category and source of personal income. Agricultural experts are optimistic about the outlook for both grain and cattle during the coming decades. The trend toward larger and more capital-intensive farms and ranches should continue. The Rosebud County economy will, however, become less dependent on agriculture and more dependent on energy development during the baseline forecast period. Diminished mining activity of any significant magnitude in Rosebud

County could significantly affect the county's economy because of the current and projected employment and income generating capacity of the industry.

2.9.2 Social Life

2.9.2.1 History

Rosebud County's social structure has gradually evolved. Until the early 1970's, no major shifts in the economic base or mass migrations had occurred. The primary economic activities in the county were agriculture and related trades. The earliest permanent settlers were livestock operators. The routing of the Northern Pacific Railroad (NP) increased growth but had little lasting influence beyond initiating small-scale coal mining in Colstrip. As a result, the resident population has become relatively homogenous in its economic activities, values, and daily activities. Areas dependent upon range livestock operations are generally sparsely populated. The residents of such areas adopt conservative, frugal lifestyles and value hard work, self-reliance, individualism, the community, the family, and cooperation. Social research conducted in the mid-1970's (Gold, 1974a, b, and c) in Rosebud County confirmed the presence of such values among area residents.

The Northern Cheyenne are a culturally distinct population residing on a reservation about 20 miles south of the Rosebud Mine. The Northern Cheyenne in the north and central sections of the reservation are the most likely to be affected by the mine. According to the Northern Cheyenne Planning Office's report and survey (August 1981), the Northern Cheyenne revere the land. The strength of their culture and spirituality is based on the natural environment. The Northern Cheyenne supplement their income through hunting, gathering, fishing, and firewood collection. They use the reservation's natural environment for recreation.

2.9.2.2 Social Structure

The major social categories within Rosebud County include agricultural ranching interests; trade service providers, primarily in Forsyth and Ashland; energy development interests, located almost exclusively in Colstrip and the immediate surroundings; and the Northern Cheyenne. Social interaction between these groups, excluding the energy group, is informal and occurs within long-standing community, friendship, and kinship networks (Gold, 1974a, b, 1975).

Interactions between the energy group and other groups is more formal. Area informants suggest that Colstrip and county residents associated with energy development are apt to be perceived and to perceive themselves as different and separate from the rest of the county. Social stratification in the nonenergy groups apparently is based on an individual's abilities in earning a living, rather than on his type of employment. Still, successful ranchers are apt to be perceived as community leaders and to be well respected. Community and county leadership, except in Coltrip, tends to

be controlled by agricultural people, who reportedly are accessible to residents and concerned about their wishes (Department of State Lands, 1981).

2.9.2.3 Values

Long-term and rural area residents value family, community, neighbors, hard work, frugality and an independent, self-reliant approach to life. They also place a high premium on the quality of the area's environment and a lifestyle that is more relaxed and socially open than that associated with more urban areas. According to survey research (Gold, 1974b, 1975a; Jobes, 1975; and Department of State Lands, 1981), it is important to county residents to be a part of the community, to know one another and to engage in social activities. Most (over 75 percent) residents report satisfaction with their lives, consider socializing important, consider people as very helpful, and would be reluctant to or would not leave the area. Most surveyed residents (70 percent of each sample) had lived in the area at least 11 years.

2.9.2.4 Other Concerns

Survey respondents in the rural areas expressed concerns that population increases would be a disadvantage of energy development. Forty-nine percent of residents surveyed in 1974, 57 percent in 1975, and 60 percent in 1981 expressed this concern. Most (over 75 percent) of residents in 1974 and 1975 (Gold, 1974b and Jobes, 1975) considered lifestyle and environmental issues as important in development decisions.

2.9.2.5 Social Indicators

Some aspects of the social environment lend themselves to simple statistical description. The data presented below were drawn from various sources to provide a statistial base with which to compare the social environment of Rosebud County with that of the State.

2.9.2.5.1 Selected Vital Statistics

Rosebud County and Montana rates of birth, death, natural increase, and deaths by selected cause are compared in Tables 19 and 20 (Appendix E). The Rosebud County birth rate was consistently above the State rate during the 1970's, although by a decreasing margin. The county death rate was below the State rate from 1975 to 1980 and above the State rate prior to that time. Both statistics may have been influenced by the increased proportion of whites in the county; residents of Indian reservations typically have higher rates of birth and death than white populations. The county rate of natural increase was consistently much higher than the State rate during the 1970's. County death rates by selected cause in most instances were well below the State rates, with the exception of accidental deaths. County accidental death rates were erratic and probably are sensitive to

the presence of small numbers. County and State infant mortality rates are compared in Table 21 (Appendix E). The county rate was erratic and generally higher than the State rate. The county's average infant death rate was 8 percent higher from 1970 to 1980 than the State rate. Infant mortality rates are regarded by health professionals as an index of the quality of an area's public health care.

2.9.2.5.2 Social Problems

Disruptive influences are present in all social groups. The data below compare the incidence and rates of common indicators of social pathology in Rosebud County and Montana. The incidence of the indicators often is higher on Indian reservations than elsewhere. The data below were not available at a level disaggregating the Indian and non-Indian populations. The presence of the Northern Cheyenne Reservation in Rosebud County may have had a disproportionate influence on the expression of these indicators.

Crime

The incidence and rates of the seven major crimes in Rosebud County and in Montana are compared in Tables 22 and 23 (Appendix E). (The reader should note that the presence of small numbers may exaggerate the listed rate, especially homicide rates and, to a lesser degree, the rates of rape.) Rosebud County rates of personal crimes of violence tend to be much higher than State rates (e.g., the decade average rate of aggravated assault is over three times the State rate) while county rates of crimes against property tend to be much lower (often less than one-half). Marked increases in the rates of personal crimes of violence in Rosebud County coincide with the initial years of large-scale energy development (1973-1977). No increase in crime against property occurred. Some of the increase in the rates of violent crime may reflect increased local law enforcement.

Alcoholism

The participation rates in community and State institutional alcoholism treatment programs for Rosebud County and for Montana are presented in Table 24 (Appendix E). The Rosebud County rates were consistently well above the State rate. The county decade average rate was over triple the State rate. A comparison of alcoholic beverage sales in Rosebud County and Montana is presented in Table 25 (Appendix E). Rosebud County per capita alcohol sales exceeded the State level from 1970 through 1975 and have been well below that level since 1976.

Divorce

A comparison of the incidence and rates of divorce in Rosebud County and Montana is presented in Table 26 (Appendix E). For most years, the Rosebud County divorce rate was well below the State rate. The county decade average divorce rate is 21 percent lower than the state rate.

Out-Of-Wedlock Births and Abortions

Comparisons of the incidence and rates of out-of-wedlock births and abortions in Rosebud County and Montana are compared in Tables 27 and 28 (Appendix E). The county rate of out-of-wedlock births was markedly higher than the State rate during the past decade. The county decade average rate was over 60 percent greater. High county rates may, at least in part, arise from the presence of the Northern Cheyenne Reservation.

In contrast to out-of-wedlock-birth rates, county abortion rates were consistently well below the State rates. The county average rate was less than one-third the State average.

Veneral Disease

The incidence and rates of veneral disease in Rosebud County and Montana are compared in Table 29 (Appendix E). County rates were markedly higher than the State rates during the 1970's. The county decade average rate was nearly four times the State rate. Rates declined in both the county and the State in 1977 and 1980, although the decline at the State level was greater.

Mental Health

Data on Rosebud County and Montana admissions to the State mental hospital are compared in Table 30 (Appendix E). The data represent poorly the true incidence of mental disease. Montana has only one State mental hospital, supplemented by five private psychiatric units. The private hospital units do not report patient origin. In addition, data reports of the five regional community mental health centers and their satellites that serve the State are unreliable. These shortcomings notwithstanding, the Rosebud County rate of mental hospitalizations has been much lower than the State rate since 1975. Prior to 1975, the county admission rate was much greater than the State rate.

2.9.2.5.3 Participation in Public Welfare Progams

Comparisions of Rosebud County and Montana rates of participation in selected public welfare programs are presented in Tables 31 and 32 (Appendix E). A comparison of county and State per capita expenditures for all public assistance programs is presented in Table 33 (Appendix E). Rosebud County participation rates in the Aid to Dependent Children program have been markedly higher than State rates in the last 11 years; however, the disparity between the county and State rates has diminished somewhat in recent years.

Rosebud County's participation in the Food Stamps program was higher than the State level from 1974 through 1981 and lower prior to 1974. County participation in the Medical Assistance program was markedly lower than State participation from 1971 to 1981. Per capita expenditures for

public assistance programs in the county were lower than in the State from 1974 through 1981. Prior to 1974, county per capita expenditures were higher than State expenditures.

2.9.3 Social and Community Services

2.9.3.1 Law Enforcement

Law enforcement in Rosebud County is provided by the county sheriff, headquartered in Forsyth, with a substation in Colstrip. The 8,600-square-foot Rosebud County Public Safety Building in Forsyth was constructed in 1979 and contains 24 detention cells. The substation in Colstrip is comprised of four cells and is generally used only as a 24-hour holding facility. The main station has excess capacity, and the capacity of the Colstrip station is considered adequate (Mountain West Research, 1981). A Northern Cheyenne facility is located in Lame Deer, but its future usefulness is questionable because it does not meet current regulations (Mcrae, 1982). There is no facility in the Ashland-Birney area. Total staff levels are adequate to serve baseline population projections, although a shift of one deputy to Colstrip may be needed during the peak population period. Current staff levels are adequate to service long-term population projections.

Sufficient patrol vehicles now exist. All vehicles are replaced biennially. Communications equipment is in good condition. The sheriff's office provides communications and dispatching services for the local emergency medical service and fire protection organizations.

2.9.3.2 Fire Protection

Fire protection in Colstrip and Forsyth is provided by volunteer fire departments. The Forsyth volunteers number 16, the Colstrip volunteers, 27. The Forsyth Fire Department is equipped with four fire trucks with 1,000-gallon tanks and 300- to 400-gpm (gallons per minute) pumps. The fire department will go to the country club and airport, and has, in case of emergency, gone outside the city. A rural fire department has been considered for areas surrounding Forsyth (Rice, 1982). The Colstrip fire department has four 1,000- to 1,500-gallon pumpers. The fourth pumper unit was delivered in the winter of 1982. The unit is a new, Superior pumper, fully equipped, mounting a 1,000-gpm pump, and is to be stored in a new heated fire station at the north end of Colstrip. The north station location was chosen to reduce the reaction time to fires in that part of Colstrip.

The Colstrip Volunteer Fire Department soon will apply to the Insurance Services Office of Montana for a Class 5 rating. The rating now held is Class 7. The force has been informed that the only impediments to the Class 5 rating are its training and record-keeping programs. Both have been improved with the intention of meeting Class 5 standards.

Service standards suggest that 10 volunteers and 1 vehicle are needed per 1,000 dwelling units, or roughly 3,000 people (Mountain West Research,

1981). These standards indicate that the Colstrip volunteer force and equipment are adequate for the projected peak baseline population. Forsyth's volunteer force is also adequate for projected peak populations.

2.9.3.3 Sanitary Sewer

Wastewater is treated in both Forsyth and Colstrip with oxidation ditch facilities. The system in Forsyth began operating in 1980, with Colstrip's treatment plant completed in early 1982. The Forsyth plant is designed to serve roughly 5,000 people, while the recent expansion of the Colstrip facility will allow it to serve 7,500 people (Mountain West Research, Inc., 1981; Connell, 1982).

2.9.3.4 Water Supply

The Forsyth public water supply is drawn from the Yellowstone River. The water intake and treatment system's capacity is rated at 3.5 million gallons per day, although its actual capacity may be less. Elevated storage capacity totals 1.35 million gallons. The water supply system is considered adequate to serve a population of roughly 5,000 (Mountain West Research, 1981). However, the present system will not service areas of expected future growth adjacent to and east and southeast of town. The town is considering installing a booster system (Rice, 1982).

The Colstrip public water supply is drawn from Castle Rock Lake, a surge (water supply) pond for the Colstrip generating units. Western Energy is constructing an expanded facility for a 4,000-gallon permitted treatment capacity and 3,680,000 gallons of storage capacity. The new system is considered adequate to meet the needs of present and projected peak baseline populations (Reardon, 1982).

2.9.3.5 Solid Waste

Rosebud County operates a 25-acre landfill near Colstrip. The site is leased from Western Energy under a renewable 10-year contract. The dump site also serves Powder River and Custer Counties and the Northern Cheyenne Reservation. The site is managed by a private contractor. No short-term capacity problems are foreseen at the current dump site for the projected baseline populations of the service areas (Tusler, 1982). Additional capacity may be needed after the year 2000 (Mcrae, 1982).

The Colstrip rural refuse disposal district is served by a three-man crew and one truck with a 25-cubic-yard compactor. Collection capacity is adequate, with one pickup day per week. The city of Forsyth collects its own solid waste and contracts with a private hauler who takes the waste to the Colstrip landfill 10 or 11 times per month. The collection system now has excess capacity and is considered adequate to serve baseline population projections. The Ashland-St. Labre collection system comprises four collection boxes serviced by two trucks and is now operating close to capacity (Mountain West Research, 1981).

2.9.3.6 Social Welfare

The social welfare programs provided by the Rosebud County Department of Public Welfare are identical to those available in all counties in Montana:

- Aid to Families with Dependent Children (AFDC)
- Medical Assistance (Medicaid and County Medical Assistance)
- Foster Care
- Food Stamps
- Social Services (Homemaker Service, Meals on Wheels, etc.)
- General Assistance
- Transient Assistance

The county headquarters is in Forsyth, with community outreach offices in Colstrip and Lame Deer. Eight nonclerical professionals staff the department (four in Forsyth, one in Colstrip, and three in Lame Deer). The Forsyth office is adequately staffed to serve the projected baseline population. It may be necessary to add one additional social worker or paraprofessional to the Colstrip staff during the peak construction period of Colstrip Units 3 and 4 (Kennedy, 1982). However, the Montana Coal Board recently awarded a $200,000 grant to Rosebud County to expand social services delivery in the Colstrip area. Of this total, $128,000 were earmarked for salaries. Additional personnel to be supported by these funds include:

- 2 alcohol/drug counselors
- 1 alcohol/drug counselor aide
- 1 school social worker
- 1 social services aide
- 1 administrative officer
- 1.5 clerical staff
- Assumption of a portion of the salary of the present Mental Health Counselor/Therapist in Colstrip.

Of the remaining $72,000, the largest single planned expenditure is $21,847 in support of the Here's-Looking-at-You Program and alcohol/drug abuse education program aimed at school children, countywide. The remaining funds are to be allocated for rent, emergency shelter for battered spouses and children, office maintenance, equipment and supplies, staff training, and other administrative costs (Keale, 1982). The additional social services and counseling staff should ameliorate the current shortage of social support services in the area.

2.9.3.7 Medical Services

Rosebud County is served by Rosebud Community Hospital in Forsyth. It has a staff of 36 personnel, has 26 licensed beds (acute and intermediate care), maternity care, emergency facilities, X-ray department, and a part-time pharmacy (Adamick, 1982).

During 1980, the hospital had a 20.9 percent occupancy rate. Since then, two additional physicians have moved to Forsyth, but the occupancy

rate has remained low due to a lack of 24-hour surgical service and long-standing pattern of residents going out of the county for hospital care (Adamick, 1982).

Patients seeking medical services not found in Forsyth may go to the Holy Rosary Hospital in Miles City, which offers a complete range of services, including an intensive care unit, radioisotope facility, psychiatric emergency services, and speech pathology. More specialized services can be found in Billings (Mountain West Research, 1981).

Three physicians and three dentists are located in Forsyth. The outpatient medical needs of Colstrip are served by the Colstrip Medical Clinic, a Southeastern Montana Rural Health Initiative (SEMRHI) Clinic. Counties served by SEMRHI are considered medically underserved and are funded by a grant from the Department of Health and Human Services. The clinics professional staff of five includes two general practitioners (one National Health Service physician). The Colstrip Dental Clinic is staffed by two dentists and three assistants.

The medical staff and facilities in Colstrip are considered inadequate to meet the projected baseline population, according to the Montana Health Systems Agency. Medical service standards indicate the rural areas should have one physician per 1,000 to 1,200 people. The long-term baseline population of Rosebud County implies that roughly 10-12 doctors should serve the area (Western Analysis, Inc., 1982; Mountain West Research, Inc., 1981). The difficulty of recruiting health manpower and the expense of facilities make it unlikely that this problem will be resolved soon.

The Eastern Montana Community Mental Health Center at Miles City administers mental health services in Forsyth and Colstrip. Both offices are staffed by one psychologist. The 1981 caseloads were about 90 in Forsyth and 50 in Colstrip. The Forsyth office may require one additional psychologist to meet current caseloads, while the Colstrip office is at maximum capacity now (Mountain West Research, 1981).

There are two ambulances in Forsyth and four in Colstrip. The emergency medical services in Forsyth consist of one full-time civil defense director and 13 part-time Emergency Medical Technicians. Colstrip is served by 11 Emergency Medical Technicians. Services are considered adequate to meet projected baseline populations (Duell, 1982; Kampf, 1982).

One public health nurse pratices in the Forsyth Medical Clinic. Recent increases in patient contacts indicate that the office may be reaching maximum capacity.

The Rosebud County Nursing Home in Forsyth has 47 skilled and intermediate care beds. The hospital had an 83 percent occupancy rate in 1980 (Montana Department of Health and Environmental Sciences, 1980). Eight beds are swing beds and can take nursing home patients.

2.9.3.8 General Government

General government consists of the full-time administrative offices principally responsible for running county and municipal government. Rosebud County employs 19 persons, Forsyth, 7. Both staff and office space are considered adequate to service projected baseline populations (Mountain West Research, 1981).

The county shop's major responsibility is the construction, maintenance and repair of county roads. Thirty-one full-time employees now staff the shop. One additional person may be hired. Thirty-two full-time employees and the existing 20,000-square-foot shop are considered adequate to service projected baseline population levels (Bilbro, 1982).

The Forsyth shop is responsible for the water and sewer systems, street maintenance, solid waste disposal, and park maintenance. The 17-person staff and 12,000 square feet of space are considered adequate to service baseline population projections (Mountain West Research, 1981).

2.9.3.9 Library

The Rosebud County Library in Forsyth, has 27,400 volumes and participates in interlibrary loan programs. The library has sufficient capacity to service projected populations. The facility was built in 1971 and has some excess capacity. The Sagebrush Federation of Libraries bookmobile serves Colstrip and Ashland.

2.9.3.10 Housing

2.9.3.10.1 Rosebud County

The number of housing units in Rosebud County increased from a total of 2,055 in 1970 to 4,363 in 1980, a 112.3-percent rise. Of the 1980 count, it is estimated that 3,764 were occupied households. About 42 percent of the county's increase occurred in Colstrip (Mountain West Research, Inc., 1981). Mobile homes accounted for almost 60 percent of new units in Rosebud County between 1970 and 1980, due to the reliance of energy growth areas on this type of housing (U.S. Bureau of the Census, 1981). The rapid growth in mobile homes in the county is reflected in the differences between Rosebud County and the State in the 1980 housing mix. Whereas the share of total multifamily housing units is similar, mobile homes make up 36 percent of the county's housing stock and only 12 percent of the State housing stock.

Baseline projections of housing demand (households) in Rosebud County, Colstrip, and Forsyth through 2010 are presented in Table 36 (Appendix E). These estimates are based on average household sizes for permanent and temporary populations. Peak housing demand in Rosebud County occurs in 1983, when 5,743 households are projected for Rosebud County--an increase of 1,979 over the 1980 figure. Households are then projected to decline by 1,677 by 1985 and then increase steadily to 5,003 by 2010.

2.9.3.10.2 Colstrip

Prior to 1968, the town of Colstrip was owned by the Northern Pacific Railroad and consisted of about 63 houses. In 1968 the Montana Power Company (MPC) bought the community and has controlled the pace and scope of commercial and residential development since. Through its subsidiary, the Sunlight Development Company, MPC has, since 1970, financed and/or constructed single-family dwellings, multiunit apartments, mobile home spaces, recreational (RV) pads, and temporary housing for the construction work force associated with both Colstrip Units 1 through 4 and Western Energy mining operations (Colstrip High School Bond Prospectus, 1981).

Between 1970 and 1980, Western Energy and MPC developed about 960 housing units in Colstrip. It has been estimated that in 1980, 1,050 units were available in Colstrip (Mountain West Research, Inc., 1981). Of the total, 250 were single-family homes, 292 were multiunit dwellings, and 508 were mobile homes (Reardon, 1982).

In January 1982, the Sunlight Development Company reported that 1,403 permanent housing units and 906 temporary units were available, and 450 more temporary units are under construction. In addition, 124 additional single-family units are proposed and 224 lots are available for development (Reardon, 1982).

Costs of housing are higher in Colstrip than Forsyth. Houses that cost $80,000 to $85,000 in Colstrip cost $50,000 to $60,000 in Forsyth. Rentals in Colstrip are $155 per month for a one-bedroom, $205 to $350 per month for a two-bedroom, and $255 to $450 per month for a three-bedroom unit. Houses rent for over $500 per month. Installed mobile homes rent for $280 to $370 per month (Mountain West Research, Inc., 1981; Reardon, 1982). Building lots are reported to cost from $22,000 to $28,000 in Colstrip, significantly more than lots sold privately north of town (Becker, 1982).

There are few vacancies in Colstrip today. Roughly 12 unsold homes are being held for Colstrip Units 3 and 4 permanent operator personnel. Few, if any, houses are available for rent. Some trailer and RV spaces are available. The bachelor camp is at 96 percent of capacity (Reardon, 1982).

Current plans are to convert the Big Timber, Stillwater, and part of the Sweetgrass mobile home pads to single-family lots after the construction phase for Colstrip Units 3 and 4. This would make available roughly 290 more lots, in addition to the 224 new lots mentioned above. Each of these lots can be used for up to three dwelling units, depending on future housing mix demand. The temporary construction work force housing will be maintained after the construction phase to house yearly maintenance crews (Reardon, 1982).

Baseline projections of housing demand in Colstrip are contained in Table 34 (Appendix E). Housing demand is expected to peak in 1983 at 2,539 units, decline 55 percent to 1,149 units in 1990 and gradually increase to 1,333 units in 2010.

2.9.3.10.3 Forsyth

In 1970, the town of Forsyth had a total year-round housing stock of 763 units, of which 702 units were occupied. Approximately 32 percent of the occupied units were inhabited by renters. Fifty-eight of the occupied units were mobile homes. By 1980, there were 932 occupied units in Forsyth, of which 697 were owner occupied, and 235 were renter occupied (a 46 percent and 5 percent increase, respectively, since 1970). Of the 1,047 total year-round units in 1980, 214 were mobile homes. This represents a 269 percent increase over the 1970 figure.

The current rental market in Forsyth is tight. Construction-related population increases have absorbed much of the available rentals. Many homes are for sale, and, reportedly, high prices have caused them to move slowly (Becker, 1982). Several lots with city services are available now; however, lack of currently available city services has slowed development. Over 90 lots are subdivided east and southeast of town. If these lots are annexed and city services made available, development would be encouraged. Ten to twelve mobile home lots are being developed near the airport, and 20 to 30 large lots north of the Yellowstone River have been subdivided and are on the market (Rice, 1982).

The baseline housing projections for Forsyth indicate that peak housing demand will occur in 1983, when 1,085 units would be needed. (see Table 34, Appendix E). This represents an increase over 1980 of 153 units, or 16 percent. Households are projected to decline by 87 units by 1985 and then gradually increase to 1,277 units by 2010.

2.9.3.11 Education

Colstrip School District #19 now operates two elementary schools and a junior-senior high school complex. The Isabelle Bills Elementary School is a masonry structure completed in 1978. It includes a large library and gymnasium, in addition to classroom and office space. In mid-January 1982, the enrollment was 370 students. Instruction is offered from kindergarten to sixth grade. Class sizes range from 17 to 28 pupils and the average class size is 20.6. Children attending the Isabelle Bills School live predominantly in the original section of the Colstrip townsite and the Castle Rock neighborhood (Tokerud, 1982).

The Big Timber, Sweet Grass, and Stillwater mobile home neighborhoods, north of the original Colstrip townsite, are served by the Pine Butte Elementary School. The school, a modular, wood-frame building, was supplemented by a new structure completed in 1982. The mid-January 1982 enrollment at Pine Butte School was 340 students, kindergarten through sixth grade. Class size ranges from 14 to 21 students and averages 17 (Tokerud, 1982).

Colstrip Junior High School, behind the high school, is a modular, wood-frame structure erected in the early 1970's to accommodate increased school enrollments associated with the construction of Colstrip Units 1 and 2. The building will have to be replaced in the near future. Combined

seventh- and eighth-grade enrollment is 158 children and the average class size is 21.1, well below the accreditation maximum size of 30 students (Tokerud, 1982).

Colstrip High School, a masonry structure, was erected in 1944 and remodeled in 1966 and 1978. A modular, wood-frame structure was recently added to the north side of the school for temporary use until the proposed new high school is completed. The new high school building will occupy 136,000 square feet of space and accommodate 500 students. It will include space for the basic educational program, vocational education, a 600-seat auditorium, 2,000-seat gymnasium, indoor swimming pool, and central food facility for the entire school district. The new school will cost $13,074,250, of which $3,370,833 is being paid for by a grant from the Montana Coal Board. When the school is completed in the fall of 1983, the current high school structure will be converted to a middle school for grades six through eight (Schye, 1982). In mid-January, 1982, the Colstrip high school enrollment was 323 students, with an average class size of 9.1.

Colstrip School District #19 now employs 170 persons, including 12 administrators, 106 professional staff, and 52 support personnel (e.g., secretaries, custodians, and cooks) (Montana Board of Education, 1976).

Forsyth School District #4 operates an elementary school (grades K-5), a middle school (grades 6-8), and a high school (grades 9-12). The elementary school was constructed in 1978 and includes 18 classrooms, a music room, and a library serving grades K-8. In the fall of 1982, the enrollment was 392 students, and the average class size was 21.8 students. The elementary district includes an area extending halfway to Colstrip, Hysham, and Rosebud that includes Vananda (Taylor, 1982).

The middle school was constructed in 1977 and includes 11 classrooms, a gymnasium, shop, and art and music rooms. The fall 1982 enrollment was 217, and the average class size 19.7. The high school was expanded and remodeled in 1981. A new auditorium was also constructed. The total cost of the work was about $2,000,000, of which $1,750,000 was supplied by a grant from the Montana Coal Board. The facility has 20 classrooms, a gymnasium and library, and a new auditorium. Fall 1982 enrollment was 204, and the average class size was 10.2, well below the accreditation maximum of 30 students. Unlimited flexibility exists to shift classrooms between schools (Taylor, 1982).

The Forsyth School District employs 43.5 professional staff, 4 administrators, and 4.5 clerical persons (Taylor, 1982).

Accreditation standards for class size established by the State Board of Education are the principal limitation to increased school enrollments. Current minimum accreditation standards limit classes to 24 in kindergarten, 26 in the first and second grades, 28 in the third and fourth grades, and 30 in grades five through eight (Montana Board of Public Education, 1976).

At present, two kindergarten sessions in the Isabelle Bills School, each with 28 students, exceed accreditation standards. All other classes

are below the accreditation standards. Using the minimum accreditation standard as a guide, the existing elementary school classroom configuration in Colstrip could accommodate up to 321 students, and the Forsyth elementary and middle school classroom configuration could accommodate roughly 816 students. In mid-January 1982, the Colstrip elementary district was being operated at about 70 percent of capacity, with 119 spaces available in the Isabelle Bills School and 202 in the Pine Butte School. The Forsyth elementary and middle schools were being operated at about 75 percent of capacity in the fall of 1982, with about 207 available spaces.

Secondary school accreditation standards limit class sizes to 30, and teacher/student loads to 160, except in instrumental and choral music, physical education, and typing (Montana Board of Education, 1976). Given the size of the physical plant and student/teacher ratio, Colstrip High School enrollment could nearly double before significant expenditures for staff or facilities would be necessary (Hofeldt, 1982).

Using minimum accreditation standards for class sizes as a guide, the expanded Forsyth High School could potentially accommodate 600 pupils, almost three times current enrollment of 204.

Baseline projections of school enrollment in the Colstrip and Forsyth school districts are shown in Table 35 (Appendix E). Elementary school enrollment in Colstrip is expected to increase to 1,431 students by 1983, decline to 846 by 1990, and then gradually increase to 927 by 2010. Enrollment in the Colstrip High School will follow a similar pattern, increasing to 547 by 1983, declining to 364 by 1990, and gradually increasing to 397 by 2010. The completion of the new Pine Butte Elementary School and the proposed new Colstrip High School will allow the school district to accommodate projected baseline school enrollments.

Projected enrollment in the Forsyth School District is also shown in Table 35 (Appendix E). Enrollment in grades K-8 is expected to peak in 1983 with 624 students, decline to 540 in 1990, and increase to 592 in 2010. High School enrollment is expected to peak in 1985 at 261 and then stabilize, reaching 274 students in 2010. Existing Forsyth School District facilities can accommodate these projected enrollment levels.

2.9.3.12 Northern Cheyenne Reservation

Unless otherwise noted, the information below comes from the Northern Cheyenne Planning Office's (NCPO) report (August 1981). No exact count of houses or occupancy rate could be provided by NCPO because of insufficient data. Housing information will therefore be omitted.

2.9.3.12.1 Tribal Government

The tribal government consists of a president (elected by a majority of popular vote) five council members (one per 200 people, elected from five districts), and a vice president (elected by fellow members of the tribal council).

2.9.3.12.2 Law Enforcement

Law enforcement on the reservation is provided by the Northern Cheyenne Police Department. Police officer conduct is the responsibility of the Northern Cheyenne Police Commission, but ultimate accountability of the department is to the executive branch of the tribal government (the tribal president). The department consists of a chief of police, seven policepersons, one jailer, five dispatchers, and one police clerk.

2.9.3.12.3 Health Services

The Indian Health Service (IHS) operates an outpatient clinic at Lame Deer. Patients requiring hospitalization can go to an IHS hospital at Crow Agency, which serves both the Crow and Northern Cheyenne Reservations.

Medical personnel at the Lame Deer Clinic include four full-time doctors, five full-time nurses, two part-time nurses, two full-time field nurses, two pharmacists, two dentists, four dental aides, one part-time optometrist, one X-ray technician, one lab technician, one health educator, and three medical-health-record technicians. When needed, the clinic contracts with additional doctors. Non-Indian patients are not served by the clinic, except in emergencies.

The ambulance service staff, in Lame Deer, consists of a project director, a secretary, eleven driver/attendants, and a varying number of dispatchers. The service uses two 1979 type-II van ambulances and one 1978 converted van.

2.9.3.12.4 Water Supply

Birney Village has one well, a pump with a capacity of 50 gallons per minute (gpm), and a 15,000-gallon storage tank. The well is sufficient to supply 20 more homes. Supplies are supplemented by a spring between Birney and Lame Deer.

Busby has three wells. Current pumping capacity is insufficient. There are two storage tanks with a 63,000-gallon capacity, a 1-day supply.

Muddy Cluster has one well and a pumping capacity of 50 gpm. Capacity is sufficient for 10 to 15 more homes, but a standby emergency pump is needed.

There are four wells at Lame Deer with a total pumping capacity of 250 gpm, enough for 40 to 50 more homes. The two storage tanks have a 200,000-gallon capacity, enough for 1 day but not enough for more homes.

Ashland has two wells with a 50 gpm capacity, enough for 25 to 30 more homes. An emergency standby pump is needed. Two storage tanks with a total 63,000-gallon capacity are more than sufficient for the community.

2.9.3.12.5 Waste Disposal Systems

The three-cell, 10-acre lagoon system serving Lame Deer has nearly reached capacity. An estimated 374 homes are connected to the system.

The Ashland district of the Northern Cheyenne Reservation has a two-cell, 4-acre lagoon system. The system has excess capacity, since two cells have never reached full capacity. An estimated 20 homes use the system.

Birney village of the Northern Cheyenne Reservation has a two-cell, 2-acre lagoon. Nine homes are connected to the system. Although the lagoon has never reached capacity, the addition of more homes would require system modification.

Muddy Cluster has a two-cell, 2-acre lagoon system serving 14 homes. About 50 more homes could be added to the system. Busby uses a two-cell, 4-acre lagoon system that serves 82 homes. A planned expansion to 11 acres will enable the system to add 75 to 100 more homes. The sewage line needs a major overhaul.

There are at least 375 homes scattered over the reservation that are not connected to community systems. Of these, 223 have known septic tanks and drainfields. The Indian Health Service plans to provide a septic tank pump truck in the near future.

2.9.3.12.6 Fire Protection

Fire protection for forests and prairie is adequately provided by the Bureau of Indian Affairs (BIA)-Forestry.

The entire reservation is protected against building and auto fires by one part-time fireman and five volunteers. One 500-gallon tank and hose truck serves the reservation. Building and auto fire protection is now inadequate.

2.9.3.12.7 Education

In September 1890, the U.S. Government built Lame Deer's first school. The school has since been expanded and become a public school of Montana. The school expects to have sufficient capacity for the present number of students, but not for more. The enrollment is now 381 students with 27 teachers and 1 nurse; 361 of the students are Northern Cheyenne and 20 children either are from other Tribes or are non-Indian.

Headstart Program has 7 centers on the reservation. The staff consists of 1 head teacher, 2 aides, and 1 nutritionist/cook per center. Enrollment is 136, of which 126 are Northern Cheyenne and 10 either are from other tribes or are non-Indian.

Busby School is a tribal school converted from a BIA-funded school. Enrollment for kindergarten through twelfth grade totals 218, 196 Northern

Cheyenne and 22 from other tribes or non-Indian. Staffing totals 36, including 32 certified teachers and 4 aides.

2.9.4 Public Finance

The following analysis of public finances in Rosebud County includes six taxing jurisdictions: Rosebud County, High School District #19 (Colstrip), Elementary School District #19 (Colstrip), High School District #4 (Forsyth), Elementary School District #4 (Forsyth), and the town of Forsyth. It also includes the townsite of Colstrip, which is owned by Montana Power Company and managed by the Sunlight Development Company. The historical analysis includes an examination of historical revenues, expenditures, taxable valuation and mill rates. The historical analysis was used in conjunction with information provided by informed officials to make the baseline projections through 2010. The projections were developed using PUFMOD, a local government public finance simulation model developed by Western Analysis, Inc. Included in this section is a discussion of Senate Bill 87, which created the Montana Coal Board, and a brief overview of the projects funded by the Coal Board in Rosebud County.

For the purpose of analysis and projections, all dollar figures have been converted to constant 1980 dollars by using the GNP implicit price deflator.

2.9.4.1 Historical Conditions

From 1970 to 1980, real per capita taxable valuation increased 8.31 percent annually in Rosebud County, due to industrial and coal development around Colstrip. Similar increases were experienced by the two school districts in Colstrip. In comparison, real per capita taxable valuation declined or increased at a much lower rate in comparable jurisdictions. Since 1975, the addition of generating Units 1 and 2 has increased the Rosebud County taxable valuation about 30 percent. Units 3 and 4 are projected to increase taxable value another 15 percent by 1986. Thereafter, Units 3 and 4 taxable valuation will decline as the property depreciates.

For Elementary District #4 in Forsyth, real per capita taxable valuation declined annually about 3 percent from 1970 to 1980; for the Forsyth High School District, which includes oil and gas development property in the northwest corner of the county, taxable valuation increased annually by nearly 6 percent over the same ten-year period. The town of Forsyth saw its taxable valuation decline in real terms by 23.5 percent over the decade.

For Rosebud County and both Colstrip school districts, total operating expenditures and total expenditures increased significantly between 1970 and 1980 (see Table 36, Appendix E). On a real per capita basis, the average annual rate of increase in the county was 8 percent for total expenditures and 6 percent for total operating expenditures. Because of the sizable yearly enrollment increases in the Colstrip schools, ranging from 150 percent to 444 percent from 1970 to 1980, real total school ex-

penditures per average number belonging (ANB) increased at most by 0.15 percent annually. Despite the increases in virtually all major expenditure categories, mill levies in these three taxing jurisdictions decreased at an annual rate of 5 to 7 percent. These declining mill rates reflect the increase in taxable valuation during this period.

Both Forsyth school districts had relatively stable enrollment patterns over the decade. The elementary district saw a 15 percent decline, the high school district, an 11 percent increase. Real total expenditures per ANB increased approximately 4 percent per annum in the elementary district and 8 percent per annum in the high school district. Because of these increases, mill levies rose 100 to 160 percent over the decade.

Revenues also increased during the 1970's. Total county revenues increased 8 percent annually and local revenues 4 percent annually. The lower local increase stemmed largely from the increased proportion of intergovernmental transfers. In 1970, intergovernmental revenues made up 5 percent of total county revenues; by 1980 they rose to 34 percent of total revenues. A similar change was experienced by other taxing jurisdictions, owing to the influx of Coal Board Grants received to mitigate the impacts of coal development. Of the $32 million of Coal Board Grants issued since 1977, approximately 51 percent have gone to Rosebud County.

Due to the decline in taxable valuation and per capita increases averaging 3 percent per annum for total operating expenditures and 9 percent per annum for total expenditures, Forsyth increased its millage rate from 43 in 1970 to 65 in 1980. Revenues also increased. Local revenues rose 4 percent per annum and total revenues 11 percent per year. The much more rapid growth in total revenues stems from increased use of intergovernmental transfers in the local budget: in 1970 they represented 7 percent of total revenues; by 1980 they made up 50 percent.

The historical public finance analysis for the Colstrip townsite covered 1977 to 1980. Changes in accounting procedures precluded the inclusion of prior years. However, the 1977 to 1980 period included much of the permanent population settlement and infrastructural development associated with the industrial and coal mining development in the area. The townsite has experienced a sizable increase of 30 percent annually in total operating expenditures per capita. Locally generated revenues per capita, in contrast, have increased only 23 percent annually. The sharper increase of expenditures compared to revenues can be explained by the increased residential, infrastructural, and community service development performed to serve the growing permanent population. Despite the differences in rates, the townsite operation has remained economically viable for Sunlight Development Company, based on available information (Reardon, 1982).

2.9.4.1.1 Montana Coal Board

The Montana Coal Board was created by Senate Bill 87, passed in 1975. The main purpose of the Board is to assist local government units (counties, cities, towns, school districts, and other governmental units)

that have expanded public services to accommodate large-scale coal development. To mitigate the financial strain on local government, the Coal Board makes grants, from the Local Impact and Education Trust Fund, to enable government to provide services and facilities needed as a result of coal development. Each grant application is judged, among other things, on the following criteria:

- Local need
- Severity of impact
- Degree of local effort
- Population changes
- Availability of funds
- Compliance with State and/or Federal law

Fifty percent of the grant money is given to those governmental units which have had or expect to have an increase in population of at least 10 percent during any 3 years since 1972. Historically, approximately 85 percent of Coal Board money has been allocated to areas experiencing population growth (Campbell, 1982). It is expected the existing high ratio will be maintained. Applicants for Coal Board money must demonstrate how their request fits into an overall plan for orderly management of growth problems.

Rosebud County has undergone coal-related growth since 1968. In that year, Western Energy reopened the Rosebud Mine, and in 1969, Peabody Coal Company opened the Big Sky Mine. Construction on Colstrip Generating Units 1 and 2 began in 1973 with construction employment peaking in 1975. Unit 1 was operational in the fall of 1975, and Unit 2 was operational in the summer of 1976. Employment at the generating units has grown steadily since 1975, and total operational employment is expected to be 243 workers. Table 37 (Appendix E) presents the construction and operations work force at the generating units for the years 1970 to 1980.

Coal mining activity increased substantially during the 1970's. Between 1973 and 1981, Western Energy received 13 mining permits from the Montana Department of State Lands. To date, 6,229 acres have been approved for mining and related activities. Table 39 (Appendix E) presents the schedule of permit applications and the date approval was granted. Total acres under permit do not equal acres shown on Table 39 (Appendix E) because expansion projects may include acreage already under permit.

Table 37 (Appendix E) shows operations and construction employment associated with the Rosebud Mine between 1970 and 1980. The greatest increase in operations employment occurred between 1970 and 1975; employment has been relatively stable since. Construction employment has generally been on an "as needed" basis. Thirty-five construction workers were required in 1975, 1976, 1979 and through part of 1980 for dragline construction.

The greatest employment growth took place before 1976. Coal Board money was not available until mid-1976. Between 1976 and 1978, grant money was used in Rosebud County to alleviate the impacts due to energy development which had already occurred. Between 1976 and April 1982, governmen-

tal units in Rosebud County received a total of $18.3 million in Coal Board Grants. The local match (property taxes, obligation bonds, and Federal dollars) amounted to $18.5 million.

Table 39 (Appendix E) presents the broad categories of public services and the amount of Coal Board money awarded for each category. School districts in the county received 55 percent of grant money and accounted for the largest share of local match ($12.5 million). Grants for sewer and water systems amounted to 32 percent ($5.8 million) of the total. Forsyth, Colstrip, and Ashland all received grants to upgrade existing water and sewage systems. In 1977, Ashland was awarded $71,080 (matched locally by $904,000) to upgrade the existing water and sewer system. However, the projected increase in population, from railroad and coal activity never materialized. In 1978, the community received another $102,844 to relieve revenue shortfalls, due to insufficient hook-ups, and to repair the upgraded system.

Table 40 (Appendix E) shows the total amount of Coal Board grants received each year in Rosebud County. The table indicates the catch-up period between 1976 and 1978. In 1980, there was a large influx of Coal Board money to accommodate the increased permanent population due to generating Units 1 and 2 and the expected population from the proposed Area C expansion and the construction of Units 3 and 4.

Most grant money has been used for capital construction (schools, community buildings, and water and sewer systems) and capital equipment (school equipment and fire trucks). Relatively little grant money has been used for human services: the largest grant to date was awarded in 1982 for the Rosebud County Comprehensive Human Services Program for approximately $200,000. As capital requirements are met in Rosebud County, the grant emphasis may shift to human services.

2.9.4.2 Baseline Fiscal Projections

Baseline fiscal projections for Rosebud County, the two Forsyth school districts, Forsyth, and Colstrip were estimated to the year 2010. Balanced budget scenarios were developed using a simulation model (PUFMOD) for the three taxing jurisdictions. The projections were developed using per capita rates of change for each of the revenue and expenditure categories in the simulation model.

This approach provides an indication of how high property taxes must be to balance the budget, given a predetermiend level of expenditures and nontax sources of revenues. Tables 41 through 46 (Appendix E) contain the baseline projections for Rosebud County, Colstrip High School District #19, Colstrip Elementary School District #19, Forsyth Elementary School District #4, Forsyth High School District #4, and Forstyh.

2.9.4.2.1 Rosebud County

The initial annual increases in real operating expenses per capita in Rosebud County (Table 41) result from the assumption of continued histori-

cal annual 4 percent increases in general government and 16 percent increases in public safety expenses through fiscal year 1983, when the population peaks. Thereafter, public safety expenditures are assumed to increase at a declining rate until 1987 when the population stablizes.

Through 1986 the historic real per capita annual rates of increase of 1 percent for public service expenditures and 5 percent for transportation expenditures are assumed to continue. These increases permit the continued development of public service and transportation services during this period of population growth. Thereafter, all operating expenditures are assumed to remain constant in real per capita terms.

Development of county government is assumed to be now near completion; therefore, capital outlays are assumed to be cut in fiscal year 1982 to their historic per capita level. Since Coal Board funds and Federal transfer payments are expected to fall off dramatically, intergovernmental revenues in turn fall by over 50 percent, to levels of prior years.

Based on these assumptions, the estimates for Rosebud County contained in Table 41 (Appendix E) show an increase of 31 to 54 percent in all but one of the major expenditure and revenue categories through fiscal year 1983. Thereafter, through 2010, there are moderate fluctuations, reflecting changes in population. Between 1982 and 1990, mill levies decrease approximately 49 percent and thereafter rise by 4 percent annually. The mill levy increase in later years is due to projected declines in taxable value, caused by decreasing coal production, the declining values of industrial plant and equipment, and a modest rise in expenditures (9 percent) between 1990 and 2010.

2.9.4.2.2 Town of Forsyth

The baseline projections for the town of Forsyth shown in Table 46 (Appendix E) show a continued real increase in both expenditures and revenues through 1983, a slight decline to a stable level until the mid-1990's, and a gradual rise through 2010. This revenue/expenditure pattern corresponds to population fluctuations.

The projections through 1983 for Forsyth are based on the continuance of recent annual increases in general government (3 percent), public safety (1 percent), public service (2 percent), transportation (2 percent), and public utility expenditures (2 percent). Thereafter, all expenditures are held constant. Capital outlays are projected to decline to their historic level by 1983, since impact mitigation and needed infrastructural development tapers off.

The revenue projections for Forsyth include an assumed 1 percent real per capita annual increase in fees, licenses, and fines and an increase of 1 percent in public utility charges through 1983. Property taxes are projected to increase 17 percent before falling off in 2009 due to the drop in debt service allocations. Given the projected revenue requirements under the balanced budget scenario and the projected taxable value, mill levies are expected to approximate their historic annual increase of 4 percent,

before falling off in 2009. The mill levies shown consider only the current year's revenue generations and do not account for the budget surpluses experienced during the 1970's which could be applied to the projected budgets, thus lessening the property tax requirements.

2.9.4.2.3 Forsyth School Districts

The baseline projections for the two Forsyth school districts are contained in Tables 44 and 45 (Appendix E). Both the elementary and high school district are expected to show up to a 32 percent increase in real expenditure and revenue requirements through 1985. Elementary District #4 is assumed to have real per student increases of approximately 2 percent in both instruction- and transportation-related expenses through 1984 as enrollment grows above current levels. County funds were assumed to continue their recent historic increase of 1 percent, and State funds their increase of 0.28 percent, during this same period. High School District #4 is assumed to have continued 2 percent rates of increase in administrative and instruction-related expenditures through the period of increasing enrollment ending in 1986. During this time, operation and maintenance expenditures are assumed to continue their 0.13 percent real increase and county revenues their 2 percent annual increase.

Given the above assumptions, taxes will continue to rise under the balanced budget scenario through 1983 in the elementary district and through 1985 in the high school district. Because of the continued decline in the elementary district taxable valuation and the projected stability due to oil development in the high school district, elementary district mill levies are expected to increase at an average rate of 4 percent per annum (as opposed to the 1970 and 1980 rate of 7 percent per annum), whereas the high school district mill levies are expected to decline less and less through 2010.

2.9.4.2.4 Colstrip School Districts

Operating expenditures per capita are assumed to stay constant at 1981 levels in both the Colstrip high school district and the Colstrip elementary district with one exception: elementary instruction expenditures are assumed to increase 6.50 percent through 1984, bringing per capita instruction expenditures back up to the 1980 peak of $2,171 per student. This increase reflects the need for additional temporary teachers. After 1984, instruction expenditures are assumed to return to historical levels.

The baseline projections for the high school district include the sale of $9.7 million in bonds, with debt service payments beginning in 1983 and extending through 2002.

Nonproperty tax school revenues are assumed to stay constant in real per capita terms, with two exceptions: (1) county funds to the elementary district continue their historic 4 percent annual increase to supplement the funding for the additional temporary teachers; (2) per student Federal funds to the high school decline 12 percent due to recent Federal funding policies.

Tables 42 and 43 (Appendix E) contain the baseline forecasts based on these assumptions. As expected, revenues and expenditures are forecast to peak in 1983 and will thereafter exhibit moderate, generally downward-trending fluctuations.

Mill levies in these two balanced budget scenarios are more erratic than those forecast for the county due to the influence of coal production and prices on the taxable valuation of the school districts.

2.9.4.2.5 Town of Colstrip

Colstrip townsite baseline projections presented in Table 47 (Appendix E) include three major capital outlays as part of the baseline assumptions. All three projects are to be funded solely by Coal Board Grants: (1) $1.1 million water treatment plant in 1981; (2) $150,000 for a new fire truck and storage facility in 1983; and (3) $300,000 for a snow blower and street cleaner in 1983 (Workman, 1982). No additional capital outlays are included in the baseline projections.

Operating expenditures are assumed to remain constant in real per capita terms with the exception of general expenditures, public services, public utilities, and housing expenditures. These four expenditures are assumed to increase through 1984 in real per capita terms at their historic annual rates (i.e. general expenditures, 3 percent; public services, 8 percent; public utilities, 14 percent; and housing, 16 percent) This will enable the continued development of townsite infrastructure and services for as long as the population continues to grow. The growth in residential and community services is assumed to be necessary to attract and maintain a permanent work force.

Real per capita revenues from housing rents and trailer park rents are forecast to decline after 1984, when the population peaks. Housing unit sales are projected to increase at a declining rate until 1987, when the population stabilizes (McIntosh, 1982).

Given the above assumptions, the Colstrip townsite managers can expect a 40 percent increase in real operating expenditures per capita by 1984, with no change thereafter. Real total expenditures and operating expenditures are forecast to peak in 1983 when the annual population peaks. Therefter, expenditures, like revenues, fluctuate moderately with a downward trend through 2010.

2.10 LAND USE

2.10.1 Regional Land Use Patterns

Coal mining and power plant construction have transformed Rosebud County from an agricultural region into a major energy development area in less than 10 years. Land use, in turn, has shifted resulting in increases in urban and industrial areas and decreases in agricultural land.

Coal development in Rosebud County has temporarily taken out of production about 3,350 acres of rangeland and 200 acres of cropland (Montana Department of State Lands, 1981). About 77 percent of the disturbance is due to the Rosebud Mine (Table 2.10-1). Additionally, about 550 acres of land at Colstrip and Forsyth have been permanently converted to urban and industrial uses (Montana Department of State Lands, 1981), with additional urban areas currently under construction at Colstrip. The cumulative impact of coal mining to date represents about 0.1 percent of the 2.5 million acres of rangeland and about 0.2 percent of the 30,000 acres of cropland in Rosebud County.

2.10.2 Local Land Use Patterns

Land uses in the Rosebud Mine area include grazing and crop production of mainly dryland winter wheat and alfalfa. Approximate acreages are presented in Table 2.10-2. Of the total undisturbed acreage in Areas A, B, C, D, and E, approximately 74 percent is grass and shrubland rangeland, 16 percent conifer rangeland, and 10 percent cropland. By comparison, in Rosebud County as a whole, 78 percent of the land is in grazing use, 4 percent in cropland, 8 percent in Indian reservation, and the remaining 10 percent in timbered woodlands and residential, industrial, and water uses (Rosebud County Planning Board, 1979).

Dryland winter wheat production in the Rosebud Mine area is similar to the county average of 29 bushels per acre. Dryland alfalfa, at an average of 0.9 ton per acre, is somewhat lower than the countywide average of 1.5 to 2.0 tons per acre (Prinkki, 1982). The alfalfa field in the railroad loop in Area A produces about 2.0 tons per acre of alfalfa, probably due to subirrigation. Although some irrigation structures have been built along East Fork Armells and Stocker Creeks, the cropland in the Rosebud Mine area is dryland, except for some spots receiving irrigation along East Fork Armells Creek every 3 years or so. According to Soil Conservation Service data presented by Hydrometrics (1981), there is potential for irrigation along parts of Stocker and East Fork Armells Creeks. The cropland at the Rosebud Mine has been designated as class III and IV under the Soil Conservation Service Land Use Classification System. This classification is considered marginal for crop production as compared to the United States as a whole; however, the rating is the best possible in southeastern Montana, given the low rainfall and a short growing season.

Rangeland is the predominant land use both in the Rosebud Mine area and in Rosebud County. Average production levels for southeastern Montana average from 0.25 to 0.30 AUM per acre (Montana Department of State Lands

TABLE 2.10-1

SUMMARY OF LAND USE IMPACTS OF THE ROSEBUD MINE

Land Use Category	Pre-mining Use	Present Use[a]
Rangeland -		
Grassland and Shrubland	16,500	14,683
Ponderosa Pine	7,440	7,290
Cropland	1,420	1,220
Mining Disturbance	640[b]	315
Mine Facilities and Associated Disturbance	0	424
Reclamation	0	2,011
Bond Release	0	57[c]
	26,000 acres	26,000 acres

[a] Estimated as of 1981 (Montana Department of State Lands, 1981).

[b] Unreclaimed spoils remaining from the original Northern Pacific Mine, and Burlington Northern Railroad right-of-way spoils.

[c] County road

TABLE 2.10-2

CURRENT LAND USE IN THE ROSEBUD MINE AREA

	Acres
AREA A	
Grass and Shrub Rangeland	2,184
Conifer Rangeland	807
Cropland	193
Under Reclamation	811
Currently Disturbed	236
Urban Development	93
	4,324
AREA B	
Grass and Shrub Rangeland	2,812
Conifer Rangeland	107
Cropland	116
Under Reclamation	213
Currently Disturbed	190
	3,438
AREA C	
Grass and Shrub Rangeland	6,349
Conifer Rangeland	512
Cropland	1,471
	8,332
AREA D	
Grass and Shrub Rangeland	1,772
Conifer Rangeland	1,415
Cropland	176
Northern Pacific Disturbance	273
	3,636
AREA E	
Grass and Shrub Rangeland	568
Conifer Rangeland	52
Northern Pacific Disturbance	805
Under Reclamation	471
	1,896
	Miles Traversed
CONVEYOR ROUTE	
Grass and Shrub Rangeland	1.4
Cropland	0.7
Northern Pacific Disturbance	0.5
Surface Disturbance	1.5
	4.1

1981). Currently, most rangeland at the Rosebud Mine is in "fair" condition based on Soil Conservation Service guidelines. Under this rating, productivity is about 0.15 AUM per acre for grassland and shrubland and about 0.2 AUM per acre for conifer rangeland. Under optimum management, this could be increased to about 0.45 AUM per acre for grassland and shrubland and to about 0.23 AUM per acre for conifer rangeland. Production levels at the Rosebud Mine can be expected to be higher along creek and coulee bottoms and would increase during years of above average rainfall.

Timber harvest in the area is now minimal. However, with increased demand for wood products, concentrated stands of ponderosa pine may become merchantable in the near future.

2.10.2.1 Area A

Land use in Area A consists primarily of grazing, with about 19 percent of the grazing land in ponderosa pine forest. About 5 percent of the area is cropland, including 125 acres in dryland wheat production and 68 acres in alfalfa production. About 2 percent of Area A is now being developed to expand the townsite of Colstrip. Part of Area A has been mined and about 19 percent of the area is being reclaimed.

2.10.2.2 Area B

About 85 percent of Area B is now used for grazing. About 6 percent is cropland, including 133 acres of alfalfa and 77 acres of dryland wheat. About 3 percent is scattered stands of nonharvestable ponderosa pine. The remaining portions have been recently disturbed by mining.

2.10.2.3 Area C

Nearly 18 percent of Area C is in cropland production, including 779 acres of dryland wheat and 692 acres of alfalfa. The remaining parts of Area C are used for grazing. Although 6 percent of Area C is in ponderosa pine forest, these scattered stands are not used for timber production.

2.10.2.4 Area D

Approximately 40 percent of Area D is ponderosa pine forest. These stands are fairly concentrated and could be harvested by a small-scale operation if there were a demand for the timber. Estimated yield from this area is now between 700 and 900 board-feet per acre. If the timber were harvested, 50 to 100 years would be required before the forest would regain its present volume.

Cropland in Area D amounts to about 5 percent of the area. Approximately 7 percent of Area D is covered by old Northern Pacific spoils.

2.10.2.5 Area E

Area E is surrounded on three sides by old Northern Pacific spoils. About 67 percent of Area E has already been disturbed by mining and 25 percent is now being reclaimed. There is no cropland in Area E; its primary use is grazing.

2.10.2.6 Conveyor Corridor

The 4-mile corridor of the conveyor between Areas C and E traverses, for half the distance, previously disturbed areas. A sixth of the distance crosses the subirrigated alfalfa field in Area A. The remaining distance crosses grass and shrub rangeland.

The conveyor corridor would also cross Castle Rock County Road, State Highway 315 (FAP 39), and the Northern Pacific railroad spur. The corridor runs along the southern end of Colstrip.

2.10.3 Federal Planning

Portions of the coal in the Rosebud Mine are federally owned and adminstered by the Bureau of Land Management. The BLM has developed a land use plan or Management Framework Plan (MFP) for the South Rosebud Planning Unit. The comprehensive plan for the Rosebud Mine is compatible with the recommendations made in the MFP.

2.10.4 Local Land Use Planning

The future land use plan for Colstrip is contained in the Rosebud County Planning Data Book and Comprehensive Plan (1979). Since Colstrip is a privately owned company town, it is not subject to city council-adopted regulations or zoning plans, although it is subject to county zoning regulations. The future land use plan for Colstrip as designed for Montana Power Company has been approved by the Rosebud County Planning Board.

2.11 TRANSPORTATION

Rosebud County's transportation network consists of a series of roadways, two railroads, five commercial truck lines, a bus line, and a county-owned and operated airport located in Forsyth. Road travel is the most common mode of transportation in the county. Graveled county roads and two-lane State highways service the Colstrip area (Figure 2.11-1). Federal Aid Primary (FAP) 39 connects Colstrip with Interstate 94, the major east-west highway to the north, and with FAP 37 (US 212), a heavily used east-west highway to the south. Access to the Rosebud Mine is along FAP 39, located about 3 miles east of the area.

2.11.1 Roads and Highways

The Montana Department of Highways is now reconstructing 31 miles of FAP 39, to meet the increased traffic resulting from coal development in the area. A 7-mile section extending south from I-94, and a 5.8-mile section at Colstrip, have already been completed. The entire project is scheduled to be completed in spring 1983 (Randall, 1982). The reconstruction includes widening the roadway, resurfacing, realignment where needed, and providing over passes at the four places where FAP 39 and the Colstrip railroad spur intersect. The theoretical capacity of the reconstructed highway is estimated to be 200 vehicles per hour (Colbert, 1982). The reconstruction is financed in part by coal severance tax, augmented with Federal Aid Primary Funds.

FAP 37, which intersects FAP 39 at Lame Deer, leads west to Busby, Crow Agency, and Hardin, and east to Broadus in Powder River County. This road is heavily used by trucks, and the Department of Highways is planning to reconstruct 27 miles of FAP 37 between Crow Agency and Busby. There is no scheduled completion date at this time.

Traffic on the major highways leading to Colstrip has increased considerably since coal development began at Colstrip (Table 2.11-1). Traffic on FAP 37 increased about 77 percent from 1968 to 1980. Traffic on FAP 39 from Colstrip to I-94 increased about 562 percent from 1968 to 1981. The majority of the increase in traffic levels is due to power plant construction; about 20 percent of the increase is contributed by mining. This increased traffic and the deteriorating road conditions made FAP 39 extremely unsafe (rated 1 on a scale of 20 by the Montana Department of Highways). The scheduled reconstruction projects should alleviate many of the road's dangers.

East Fork Castle Rock Road runs west from Colstrip to the Rosebud Mine. Other private roads also run through sections of the mine.

2.11.2 Railroads

A railroad spur connects Colstrip and the Burlington Northern mainline. The mainline is located about 25 miles north of Colstrip (Figure 2.11-1). The spur serves both the Rosebud Mine and Peabody Coal Company's

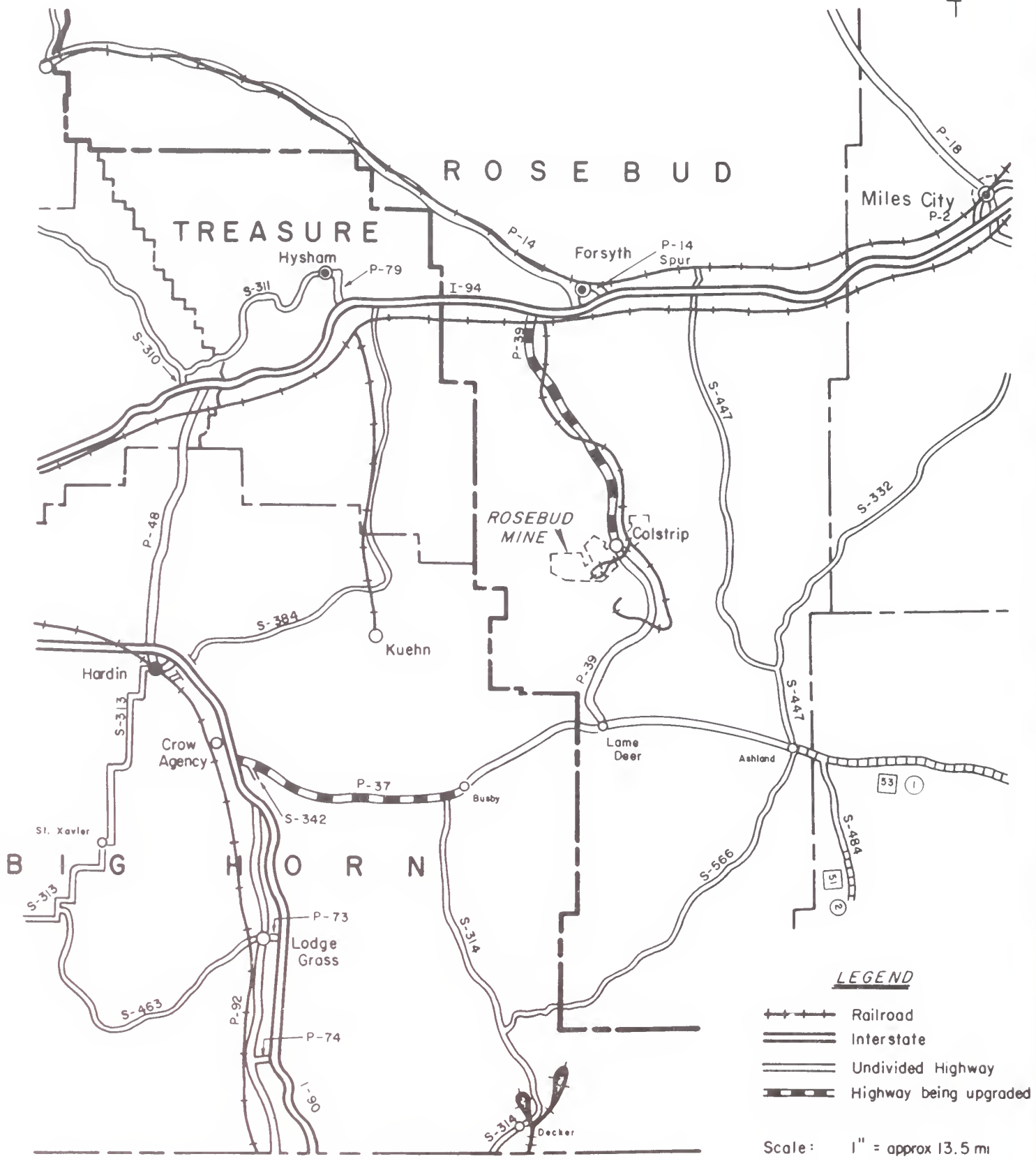


FIGURE 2.11-1 TRANSPORTATION ROUTES NEAR COLSTRIP

TABLE 2.11-1
AVERAGE DAILY TRAFFIC COUNTS FOR HIGHWAYS NEAR COLSTRIP, 1968-1981

Highway Segment	Year													
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
FAP 37														
Jct. 342 to Busby.....	673	603	657	701	766	860	778	791	1,052	1,443	1,159	1,130	1,250	---[1]
Busby to Rosebud County line.....	782	773	802	766	854	924	914	1,072	1,223	1,585	1,153	1,130	1,250	---[1]
Rosebud County line to Lame Deer.....	858	850	863	820	962	1,033	1,011	1,263	1,243	1,800	1,370	1,130	1,590	---[1]
FAP 39														
Lame Deer to Reservation boundary.....	238	274	320	363	395	---	---	---	359	511	585	640	1,180	---[1]
Reservation boundary to Colstrip.....	159	170	195	203	269	508	451	498	388	344	364	340	610	---[1]
Colstrip to I-94 interchange.....	210	190	236	253	370	1,193	1,047	1,425	1,087	783	678	570	1,270	1,390[2]

1 Data for 1981 not yet compiled.
2 ADT from permanent counter located 6 miles south of the Colstrip Interchange.

[Source: Montana Department of State Lands, 1981; Bill Colbert, Montana Department of Highways, 1982]

Big Sky Mine, 7.5 miles south of Colstrip. Coal from the Rosebud Mine is shipped to such places as Billings, Montana; St. Paul, Minnesota; and Bayfront, Wisconsin. Sometimes the Colstrip spur is also used to haul heavy machinery for construction projects. An average of three loaded unit trains per day used the Colstrip spur in September 1981, for a total of six trips per day, counting returning empty trains (Coefield, 1982).

2.11.3 Other Networks

A power transmission line runs through the Rosebud Mine, leading west from Colstrip. A private landing strip is located south of Colstrip. No significant pipelines (gas or water) pass near the mine.

2.12 RECREATION

2.12.1 Urban Recreation Resources

Most formal recreational activities in Colstrip are provided by the Colstrip Area Recreation and Parks Association (CARPA), a citizen organization concerned with recreation in Colstrip. The organization is supported by contributions from the energy corporations located in Colstrip (about 90 percent of the total capital and operation budget) and fees from association memberships. At present, CARPA numbers 287 family, adult, and youth memberships (Noyd, 1982). Resources available under the aegis of CARPA include a 51-acre park system, a swimming pool, a wading pool, three tennis courts, three basketball courts, and five playgrounds for young children. Indoor facilities are provided at the Colstrip Community Center and comprise 16,000 square feet of space allocated to two handball/racquetball courts, a weight/exercise room, a basketball court, and a meeting room (Colstrip High School Bond Prospectus, 1981). Other indoor facilitites include a library and meeting hall (CARPA Recreation Guide, 1980). Colstrip is now building a new outdoor recreation complex, to be named Stillwater Park, which will be comprised of one baseball and two softball fields, a soccer field, an outdoor basketball court, and a playground area (Mountain West Research, Inc., 1980). Other recreational improvements planned for completion before 1985 include a golf course, equestrian area, and additional ballfields (1980 Update of the Rosebud County Plan).

Nearly 60 percent of residents surveyed by Western Analysis (1982) considered the adequacy of organized recreation in Colstrip to be good to excellent. Over 51 percent considered the amount of Colstrip area recreational opportunities to be adequate to great; about 45 percent considered them to be limited or insufficient. Popular organized recreational activities of surveyed residents include baseball/softball (40 percent), movies/dining (83 percent), dancing (55 percent), and bowling (46 percent). Facilities for these activities are limited in Colstrip, except for baseball/softball fields.

2.12.2 Nonurban Recreation Resources

Developed public recreation resources in the area are limited. Four Federal, four State, and one private nonurban recreation sites have been developed within the county. Table 2.12-1 summarizes facilities and activities available at the sites.

The U.S. Forest Service manages 95,827 acres of forest land for recreational purposes within the county and maintains 217 miles of road access within that region (Montana Department of Fish and Game, 1978). In addition, some 230,000 acres of public land managed by the Bureau of Land Management are available for public use. These areas offer activities such as hiking, camping, horseback riding, vehicular recreation, and other trail activities, including snowmobiling and cross-country skiing. A motorcross course, rodeo grounds, and the Rosebud Park are available in the Forsyth vicinity (Montana Department of State Lands, 1981).

TABLE 2.12-1

NONURBAN DEVELOPED RECREATION SITE INVENTORY - ROSEBUD COUNTY

DESCRIPTION	FACILITIES/ACTIVITIES			
Name	Picnic Units	Camp Units	Other*	Fee
FEDERAL OWNERSHIP				
1. Poker Jim Butte	3	0		$0
2. Crazy Head Springs	3	5	S, F	0
3. Green Leaf	0	0	F	0
4. Lost Leg	0	0	F	0
STATE OWNERSHIP				
1. East Rosebud	5	0	F, FT	0
2. Far West	0	0	F, FT	0
3. West Rosebud	0	10	F, FT, BA	0
4. Forsyth Rest Area	5	0	I, W	0
PRIVATE AND NONPROFIT				
1. Wagon Wheel	0	20	TC, W, F	3

*KEY: Facilities/Activities - Other

F - Fishing
I - Information or interpretive exhibits
S - Swimming area
TC - Trailer/camper hookups
W - Waste disposal station
BA - Boat access
FT - Float trips

Abstracted from 1978 Montana Statewide Comprehensive Outdoor Recreation Plan (SCORP), Volume 2, Outdoor Recreation Inventory

The Tongue River Reservoir, located in Bighorn County, is about 55 miles south of Colstrip. The reservoir is largely undeveloped for recreation, although three primitive camping areas exist nearby. The reservoir fishery offers a number of warm-water game species. The Tongue River below the reservoir also offers recreational opportunities and sustains a trout fishery in its upper reaches and a warm-water fishery downstream from Birney. Access to the river upstream from Ashland, however, is limited by private owners and the Northern Cheyenne Indian Reservation. The Bighorn Canyon National Recreation Area, located about 70 miles southwest of Colstrip, is a major recreation site, providing boating, swimming, hiking, picnicking, and camping opportunities. The Yellowstone River also is available for boating, fishing, and other recreational activities; two fishing access sites and two recreation areas are located on the river near Forsyth (Mountain West Research, 1980). Montana Power Company allows access to Castle Rock Lake, the 152-acre surge pond that provides make-up water for the Colstrip generating units and the Colstrip public water supply (Williams, 1982). Additionally, Rosebud and Sarpy Creeks provide fishing opportunities near Colstrip.

Hunting is also available near Colstrip. Predominant game animals in southeastern Montana include mule deer, white-tailed deer, pronghorn antelope, praire grouse, upland game birds, turkey, and waterfowl. Other wildlife recreation opportunities include fur trapping, bird watching, and rabbit hunting.

The results of recreation surveys conducted in 1976 and 1977 by State authorities indicated that area residents prefer recreation in undeveloped, natural areas. Other studies indicate a high willingness of Montanans to travel out of the immediate area for recreation (Montana Department of Fish and Games 1978). A survey conducted by Western Analysis (1982) confirms these findings. Over 75 percent of surveyed adults camp, picnic, hunt, or fish. Sixty-seven percent enjoy swimming. Outdoor recreation in the Colstrip area reportedly is not now approaching the capacity of the area's recreational resources (Montana Department of State Lands, 1981). Still, Federal authorities anticipate increased demands for recreation, particularly motorized recreation, picknicking, overnight camping, and fishing. Federal land resources are to be managed to satisfy such demands (Mountain West Research, 1980).

2.13 CULTURAL RESOURCES

Much information on the cultural resources of the Rosebud Mine area exists in a number of reports dating from 1972 to the present. The majority of the work in the project area has been conducted by the staff of Mineral Research Center, Cultural Resources Division, Montana Tech Alumni Foundation. For these studies, mining areas A-E were defined as the direct impact zone. A 1-mile strip around the direct impact area was called the buffer zone. This zone, required by DSL, is meant to preserve, to the extent possible, important cultural resources from the effects of blasting. Blasting can affect rock art, rock shelters, and sites with standings structures. The reports describe the surveys and excavations that have taken place in both the direct impact and buffer zones and contain information on sites and activity areas, their significance, and some recommendations for mitigation. The information presented in this document is based on a 1982 review by Professional Analysts of all the cultural resources reports (Hanchette and Deaver, 1982). Table 2.13-1 lists the reports and/or fieldwork.

Many types of cultural evidence have been recorded in the mine area. In general, prehistoric sites were defined as those cultural manifestations that contain a minimum of (1) five recognizable tools, (2) a minimum of 25 flakes, and/or (3) one feature (e.g., hearth) within a 25-square-meter area. Cultural remains that did not meet these minimum criteria were designated as Minimal Activity Loci (MAL's).

A review of the cultural resources work in the project area showed that all of the direct impact areas except for portions of Area C have been adequately surveyed for cultural resources. Buffer zone areas need to be surveyed only for rock art, rock shelters, and standing structures, since these are the only types of sites that could be indirectly impacted by mining. The review of the cultural resources work done to date shows that portions of the buffer zone have not yet been surveyed. Figure 2.13-1 shows all areas surveyed and indicates intensity of coverage.

A total of 121 sites were recorded, including 80 in the direct impact zone and 41 within the 1-mile buffer zone:

Direct Impact Zone		Buffer Zone	
Area A:	7	TOTAL:	41
Area B:	7		
Area C:	37		
Area D:	28		
Area E:	1		
TOTAL:	80		

A determination of eligibility for placement on the National Register of Historic Places (NRHP) has not been conducted for all sites. (The determinations are made in consultation with the State Historic Preservation Office (SHPO), the Office of Surface Mining (OSM), DSL, and the Keeper

TABLE 2.13-1

REPORTS AND/OR FIELDWORK PERTAINING TO ROSEBUD MINE
DIRECT IMPACT AREA AND BUFFER ZONE

Reference	Date of Fieldwork	Description of Report Contents	Number of Sites Located	Comments
Fredlund, D. 1972	July-August 1971	Survey of nearly 10,000 acres in portions of Area A and B.	6	University of Montana Statewide Archaeo-
Fredlund and Fredlund, 1974	June-July 1973	Survey of 14,000 acres in portions of Area B, C, D and buffer zone.	34	Mineral Research Center
Fredlund, D.	April 1976	Description of survey of Sec. 29, T1N, R41E; portion of Area A and buffer zone.	No sites; one example of historic writing on rock panel.	Mineral Research Center
Lahren 1977	1976	Survey of scattered portions of Areas A, B, C, D and E.	Sites recorded were either lumped with sites found by MRC or given "minimal activity loci" status.	Anthro Research, Inc., under contract with USGS
Fredlund, D. and Kaestner (no report)	1976	Recloated and reevaluated lithic scatters recorded by lahren (1977) in Area E.		Mineral Research Center
? (information from site forms)	1977-1978 1981	Survey in Area D.	17 new sites; 6 sites relocated	Mineral Research Center
Fredlund, L. 1980a	May-July 1978 and May-June 1979	Survey of approximately 24,000 acres in Areas B and C and 1-mile buffer zone. Included are a review and reevaluation of sites located during 1973 survey (Fredlund and Fredlund, 1974).	50 new sites; 13 sites re-evaluated.	Mineral Research Center
Munson 1980	June-July 1978	Excavation of Old Homestead Kill Site (24RB1014) in Area A/B. Site was recorded by D. Fredlund (1972).		Mineral Research Center
Fredlund, L. 1979a	November 1978	Survey of Area A, re-survey of portions of Area A surveyed in 1971, and reevaluation of previously recorded sites.	3 new sites; 8 sites reevaluated (from Fredlund 1972 and Lahren 1977).	Mineral Research Center

*Includes only sites, not MAL's (Minimal activity loci).

TABLE 2.13-1 (continued)

Reference	Date of Fieldwork	Description of Report Contents	Number of Sites Located	Comments
Fredlund, L & Staff 1980a	1979	Survey of Area B (Sec. 4, 9, 10) and buffer zone.	5 new sites recorded.	Mineral Research Center
Fredlund, L & Staff 1980b	1979 1980	Survey of Area B (Sec. 7, 8, 17, 18) and buffer zone. Sec. 20, T1N, R41E surveyed as portion of B buffer zone.	1 site; 2 historic homesteads in buffer zone.	Mineral Research Center
Munson & Munson 1980a	May-June 1979	Survey of Peabody Big Sky Mine, Area A. Involved portions of Area B and E buffer zones of Rosebud Mine.	15 in project area (buffer zone).	Mineral Research Center
Fredlund, L. 1979b	July 1979	Reassessment of Cultural resources in Area E.	None	Mineral Research Center
Steere 1980	Oct-Nov 1979	Preliminary excavation of Sly Bison Site (24RB267).		Mineral Research Center
McGinnis 1979	Dec 1979	Resurvey of Area E to reevaluate previously recorded resources.	None	Mineral Research Center
Fredlund, L. & Staff 1980c	1980	Tested and evaluated R.S. Kimball site (24RB270) in Area B and inventoried NE1/4 sec. 11, T1N, R41E for rock art and standing structures (buffer zone).	No new sites.	
Fredlund, L. 1980b	None	Report on sites in Area E buffer based on previous surveys.	None	
Steere 1982	July-August 1981, Nov 1981	Survey of Area C, Blocks I and II (core areas). Five previously recorded sites were tested.	14 new sites; previously recorded site evaluated.	Mineral Research Center

*Includes only sites, not MAL's (Minimal activity loci).

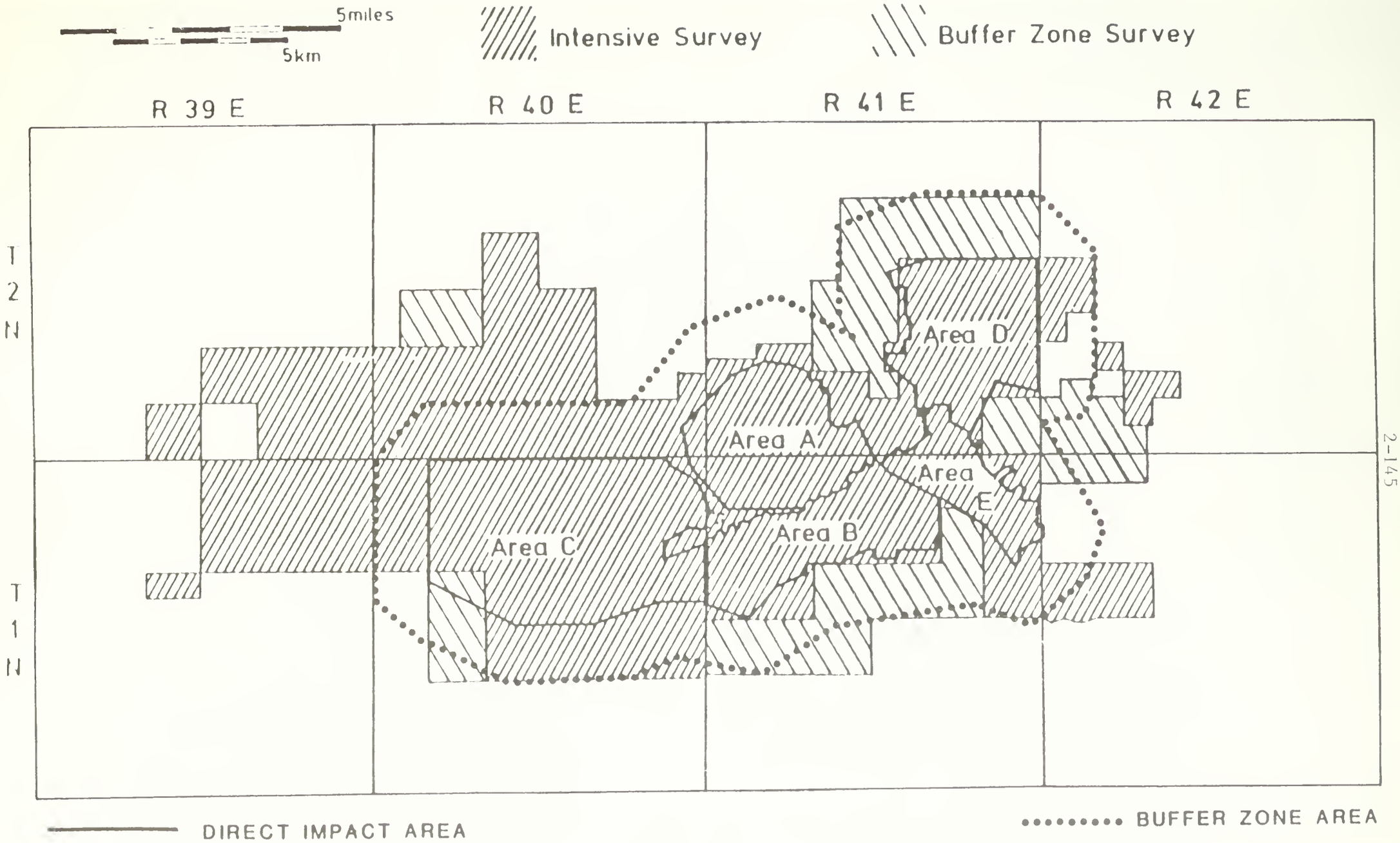


FIGURE 2.13-1 MAP OF PROJECT AREA SHOWING LANDS SURVEYED FOR CULTURAL RESOURCES

of the Register.) Below, however, is a summary of the current or probable NRHP status for the sites in the mine area. When a final determination has not been made, NRHP information is based on recommendations made by the archeological consultants that recorded the sites:

Area	Determined Eligible	Determined Ineligible	Appear Eligible	Do not Appear Eligible	No Information	Need Additional Work
A	3	1	0	2	0	0
B	1	5	0	0	2	0
C	6	15	3	4	0	9
D	1	0	3	24	0	0
E	0	1	0	0	0	0
Buffer Zone	9	4	5	17	6	0
TOTAL	20	26	11	47	8	9

Information about each site by mining area or buffer zone is presented in Tables 2.13-2 through 2.13-7. It should be remembered that additional work is ongoing and that prior to any permit issuance, cultural resource compliance will be completed.

No Native American concerns, as defined under the American Indian Religious Freedom Act of 1978 (P.L. 95-341), were identified for the direct impact areas or buffer zone. Much of the work conducted in the project area was done prior to the law's enactment, and consultations specific to this act with Native American groups, such as the Crow and Cheyenne, have not been made. However, contact has been made through the public review process. Two types of sites in the mine area may have religious significance: (1) vision quest structures and (2) sites containing rock art.

Two sites in the direct impact area (Gene's Vision Quest - 24RB1072 and Lynn's Square - 24RB1071) and one site in the buffer zone (Dead Pine rock Structure - 24RB161) were recorded as possible vision quest structures. With current information, none can be identified positively as a vision quest structure. Lynn's Square was tested and yielded no cultural remains. Both Gene's Vision Quest and Deak Pine Rock Structure are close to historic homesteads and, hence, may represent children's forts.

Five sites within the direct impact area and 3 within the buffer zone contain rock art. Information on these sites is presented in Table 2.13-8. Physical examination of the sites does not allow one to determine if they have religious significance, as most are badly eroded.

TABLE 2.13-2

SITES IN PROJECT AREA: DIRECT IMPACT AREA A (6 SITES)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
1	24RB267	Sly Bison Site	5-31-79	Fredlund 1980a Steere 1980; Fredlund and Staff 1980b	bison kill and processing area	E	Late Prehistoric
2	24RB1015	Cattail Site	1971	Fredlund, Dale 1972; Fredlund and Staff 1980b	lithic scatter	-	
3	24RB1019	Ellison Petroglyph Site	1971	Fredlund, Dale 1972; Fredlund 1979a	prehistoric petroglyph	E	
4	24RB1020	Ellison Rock Site	1971	Fredlund, Dale 1972; Fredlund 1979a	habitation	E	Late Prehistoric?
5	24RB1022	Farley Ridge Site	1971	Fredlund, Dale 1972; Fredlund 1979a	lookout/ lithic scatter	I	Late Archaic?
6 *	24RB1033	Western Energy Shelter Site	1971	Fredlund, Dale 1972; Fredlund 1979a	rock shelter with lithic and historic debris	-	

* This site number is currently being changed due to duplication of numbers

E = Determined Eligible
I = Determined Ineligible
- = Recommended as Ineligible by Consultant

TABLE 2.13-3

SITES IN PROJECT AREA: DIRECT IMPACT AREA B (7 SITES)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
1	24RB95	West Homestead Site	5-21-78	Fredlund and Staff 1980a, b, and c	Historic homestead	I	Historic
2	24RB96	Well Collected Site	5-23-78	Fredlund and Staff 1980a, b, and c	Campsite/ lookout	I	
3	24RB252	How Dry I Am Site	7-09-79	Fredlund and Staff 1980c	Temporary campsite	I	
4	24RB270	R. S. Kimball Site	12-02-79	Fredlund and Staff 1980a, b, and c	Open occupation	I	
5	24RB327	No information	5-18-80	None	Lithic scatter/ rings	NI	
6	24RB1014	Old Homestead Site and Kill	1971	Fredlund, Dale 1976; Munson 1980; Fredlund and Staff 1980a, b and c	Bison kill	I	Late Pre-historic
7	24RB1031	No information	1972	None	Rock Shelter	NI	

I = Determined Ineligible
NI = No Information

TABLE 2.13-4

SITES IN PROJECT AREA: DIRECT IMPACT AREA C (37 SITES)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
1	24RB299*	Fadhl Kill Site Lookout Site	7-22-81 6-29-78	Fredlund 1980a; Steere 1982	Bison kill	E	Late Prehistoric
2	24RB874	In Site	7-24-81	Steere 1982	Occupation/ habitation	E	Late Prehistoric
3	24RB875	P.E. Davis Rock Art Site	7-24-81	Steere 1982	Prehistoric and historic rock art	I	
4	24RB876	Wheatfield Vista Site	7-28-81	Steere 1982	Occupation/ lithic/scatter	I	
5	24RB877	Connie's Art Gallery	7-24-81	Steere 1982	Prehistoric and historic rock art	I	
6	24RB878	Foresite	7-26-81	Steere 1982	Rock Shelter	NRG-AWR	
7	24RB879*	Medicine Root Site	7-22-81	Steere 1982	Occupation/ lithic scatter	NRG-AWR	Late Plains Archaic
8	24RB880	Pigeon Site Site	7-13-81	Steere 1982	Occupation/ Lithic scatter	I	
9	24RB881	Sunburn-Out Site	7-22-81	Steere 1982	Hunting/lookout/ lithic scatter	I	Probably Late Prehistoric
10	24RB882	Gar Vadar Site	7-19-81	Steere 1982	Stone circle/ lithic scatter		
11	24RB883	Normand Estates Site	7-19-81	Steere 1982	Occupation/ hunting camp	I	Late Prehistoric
12	24RB884*	Fadhl Homestead Site	7-28-81	Steere 1982	Historic homestead	E	Historic
13	24RB885	Albino Deer Site	7-13-81	Steere 1982	Lithic work area	I	

* = Block I; Block II sites, for which there is no detailed mine plan, may not be correctly placed in the direct impact area.

E = Determined Eligible
I = Determined Ineligible
NRG-AWR = No Recommendation Given, Additional Work Required

TABLE 2.13-4 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
14	24RB886	East Fork Site Site	7-17-81	Steere 1982	Lithic work area	NRG-AWR	
15	24RB873	Tripoint Site	7-26-81	Steere 1982	Hunting/ lookout	E	Archaic historic
16	24RB1058	Farley Lookout Site	7-13-81	Fredlund and Fredlund 1974; Fredlund 1980a; Steere 1982	Lookout/ occupation	E	Late Pre-historic
17	24RB1059*	Cooley Site	7-14-83	Fredlund and Fredlund 1974; Fredlund 1980a; Steere 1982	Temporary occupation/ processing	+	Late Plains Archaic and late Pre-historic
18	24RB1060*	Three Ring	7-27-73	Fredlund and Fredlund 1974; Fredlund 1980a	Stone circles	I	
19	24RB1061	Rocky Top Site	7-21-73	Fredlund and Fredlund 1974; Fredlund 1980a	Temporary occupation	I	Late Pre-historic?
20	24RB1062	Pottery Site	7-18-73	Fredlund and Fredlund 1974; Fredlund 1980a; Steere 1982	Open occu-pation	I	Late Pre-historic after A.D. 1600
21	24RB1064	Cooley Place	7-19-73	Fredlund and Fredlund 1974; Fredlund 1980a	Historic homestead	E	Historic
22	24RB1065	Doc Taylor Place	7-8-73	Fredlund and Fredlund 1974; Fredlund 1980a; Fredlund and Staff 1980b	Historic homestead	E	Historic
23	24RB1066	Rasmus Swelk Homestead	7-24-73	Fredlund and Fredlund 1974; Fredlund 1980a	Historic homestead	NRG-AWR	Historic

* = Block I; Block II sites, for which there is no detailed mine plan, may not be correctly placed in the direct impact area.

E = Determined Eligible
I = Determined Ineligible
+ = Recommended as Eligible by Consultant
NRG-AWR = No Recommendation Given, Additional Work Required

TABLE 2.13-4 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
24	24RB1067	Caskey 320	7-24-73	Fredlund and Fredlund 1974; Fredlund 1980a	Historic homestead	I	Historic
25	24RB1069	Dusty Shelter Site	7-25-73	Fredlund and Fredlund 1974; Fredlund 1980a	Rock Shelter lithic debris	I	
26	24RB1071	Lynn's Square Site	7-27-73	Fredlund and Fredlund 1974; Fredlund 1980a	Rock structure, possibly vision quest or possibly historic	I	
27	24RB1072*	Gene's Vision Quest Site	7-28-73	Fredlund and Fredlund 1974; Fredlund and Staff 1980b	Rock structures, U-shaped (for vision quest?)	I	
28	24RB315	Waste of time	6-2-79	Fredland and Staff 1980b	Collapsed dugout	-	Historic
29	24RB326	Buteo Log Structure	7-3-79	Fredland and Staff 1980b	Collapsed log structure	-	Historic
30	24RB328	Pinkerton Homestead	7-5-79	Fredland and Staff 1980b	Log cabin, outhouse & shed, cellar	NRG-AWR	Historic
31	24RB331	Model T Homestead	6-6-79	Fredland and Staff 1980b	Auto frame, cabin, other structure	-	Historic
32	24RB332	Castle Rock Community Center	6-7-79	Fredland and Staff 1980b	House, barn, coop & outhouse	NRG-AWR	Historic
33	24RB334	Flynn Homestead	7-5-79	Fredland and Staff 1980b	Cabin, farm equipment & out buildings	NRG-AWR	Historic

I = Determined Ineligible
- = Recommended as Ineligible by Consultant
NRG-AWR = No Recommendation Give, Additional Work Required

TABLE 2.13-4 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
34	24RB391	Ashenhurst Monument	1979	Fredland and Staff 1980b	Rockpile (sheep herder monument)	-	Historic
35	24RB287	Blackbird Draw Site	6-3-79	Steere, 1982	Lithic scattering	NRG-AWR	--
36	24RB329	Pinkerton Rocks Log Shed	7-5-79	Fredland and Staff 1980b	One log shed	NEG-AWR	Historic
37	24RB330	West Fork Homestead	6-2-79	Fredland and Staff 1980b	Cabin, barn, cellars, shed, farm equipment, & misc. articles	+	Historic

+ = Recommended as Eligible by Consultant
- = Recommended as Ineligible by Consultant
NRG-AWR = No Recommendation Give, Additional Work Required

TABLE 2.13-5

SITES IN PROJECT AREA: DIRECT IMPACT AREA D (28 SITES)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
1	24RB863	Beauregard's Lookout Site	12-81	None	Open occupation	-	Late Prehistoric
2	24RB864	Drifter II Site	12-81	None	Open occupation	-	
3	24RB866	Kracked Krok Site	12-81	None	Open occupation	-	Archaic
4	24RB865	Needmore Site	12-81	None	Open occupation/ chipping station	-	
5	24RB859	Right Now Site	12-81	None	Open occupation/ scatter	-	
6	24RB871	Sandrock Industrical Site	12-81	None	Prehistoric petroglyph/ open occupation	I	Late Archaic
7	24RB870	Stack View Site	12-81	None	Open occupation	-	
8	24RB861	Three Cluster Site	12-81	None	Open occupation	-	
9	24RB860	Three Dead Pine Site	12-81	None	Campsite	-	Archaic (posibly
10	24RB862	Under the Table Site	12-81	None	Open occupation	-	Archaic
11	24RB867	Undersite Dugout	12-81	None	Historic dugout	-	Historic
12	24RB476	Prospector Drive Site	4-23-81	None	Campsite	-	

I = Determined Ineligible
- = Recommended as Ineligible by Consultant

TABLE 2.13-5 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
13	24RB478	Power Quarry Site	4-18-81	None	Material testing and knapping station	E	
14	24RB1041	Three Lobe Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
15	24RB1042	Departure Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
16	24RB1043	Jay Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
17	24RB1044	Garbage Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
18	24RB1045	Fuzzy Bird Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
19	24RB1046	Peter's 12 Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
20	24RB1047	Forces Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
21	24RB1048	Little Deer	12-81	Fredlund and Fredlund 1974	Open occupation	I	
22	24RB1049	July 4th Site	12-81	Fredlund and Fredlund 1974	Open occupation/ lithic scatter	-	
23	24RB1050	Two Deer Spring Site	12-81	Fredlund and Fredlund 1974	Open occupation/ lithic scatter	-	
24	24RB1051	Half Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
25	24RB1052	Drifter I Site	12-81	Fredlund and Fredlund 1974	Open occupation	I	

E = Determined Eligible
I = Determined Ineligible
- = Recommended as Ineligible by Consultant

TABLE 2.13-5 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
26	24RB1053	Mourning Dove Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
27	24RB1057	Horse Canyon Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	
28	24RB1073	Chipping Station Site	12-81	Fredlund and Fredlund 1974	Open occupation/ material procurement	-	

- = Recommended as Ineligible by Consultant

TABLE 2.13-6

SITES IN PROJECT AREA: DIRECT IMPACT AREA E (1 SITE)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
1	24RB266	Alan's Petroglyph Site	Summer 1973	Fredlund 1979b	Prehistoric petroglyph	I	

I = Determined Ineligible

TABLE 2.13-7

SITES IN BUFFER ZONE (INDIRECT IMPACT AREA) (41 SITES)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
1	24RB97	Big View Quarry Site	5-18-78	Fredlund and Staff 1980a, c	Quarry	-	
2	24RB98	Happy Hoofer Site	5-22-78	Fredlund and Staff 1980a, c	Material testing/workshop	-	
3	24RB161	Dead Pine Rock Structures	11-07-78	Fredlund 1979a	Three rock structures, possibly vision quest or fortification structures	+	
4	24RB162	Tumbled Stead Homestead	11-07-78	Fredlund 1979a	Historic log cabin	-	Historic
5	24RB163	Mellow Winds Shelter	11-07-78	Fredlund 1979a	Rock shelter with lithic debris	+	
6	24RB253	Tim's Shelter Site	1971	Munson and Munson 1980a	Rock Shelter prehistoric	E	1190 + 90 years-- A.D. 760
7	24RB254	Sandrock Bison Kill Sites	1971	Munson and Munson 1980a	Bison kill	E	
8	24RB255	Big Chopper Site	1971	Munson and Munson 1980a	Possible bison kill/ butchering site	-	
9	24RB256	Slewfoot Site	1971	Munson and Munson 1980a	Open occupation	E	Duncan (Middle Archaic)
10	24RB257	Crying Hawk Site	1971	Munson and Munson 1980a	Open occupation	E	Late Prehistoric
11	24RB258	Songbird Quarry Site	1971	Munson and Munson 1980a	Quarry site	-	
12	24RB265	Ambers-Heather Site	1971	Munson and Munson 1980a; Fredlund and Staff 1980b	Open occupation	-	Late Prehistoric

E = Determined Eligible
\+ = Recommended as Eligible by Consultant
\- = Recommended as Ineligible by Consultant

TABLE 2.13-7 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
13	24RB281	Wounded Nighthawk Site	7-21-79	Fredlund 1980a; Fredlund and Staff 1980b	Lithic scatter	-	
14	24RB284	River Site	7-08-79	Fredlund 1980a	Specific activity	-	
15	24RB285	Little Knob Quarry Site	7-21-79	Fredlund 1980a; Fredlund and Staff 1980b	Quarry	-	
16	24RB292	Little Cave Site	5-25-78	Fredlund 1980a	Rock Shelter/ workshop	+	
17	24RB301	Lovelace Memorial Site	5-28-78	Fredlund 1980a	Historic and prehistoric rock art/ lithics	-	
18	24RB302	Petro City Site	5-28-78	Fredlund 1980a	Prehistoric petroglyphs/ lithic scatter	I	
19	24RB303	MacDonald Quarry Site	6-29-78	Fredlund 1980a	Quarry/ workshop	I	
20	24RB307	Wouldn't-Cha-Know Site	5-25-78	Fredlund 1980a	Lithic workshop/ encampment	+	
21	24RB310	Rabbit Ridge Site	5-27-78	Fredlund	Encampment	I	
22	24RB313	Muskrat Homestead Site	1971	Munson and Munson 1980a; Fredlund and Staff 1980b	Historic homestead	E	Historic
23	24RB333	Smith Homestead Site	7-05-79	Fredlund 1980a	Historic homestead	+	Historic
24	24RB335	Castle Rock Post Office Site	?	Fredlund 1980a	Historic homestead and post office	E	Historic

E = Determined Eligible
I = Determined Ineligible
+ = Recommended as Eligible by Consultant
- = Recommended as Ineligible by Consultant

TABLE 2.13-7 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
25	24RB337	Picture Window Homestead	9-04-79	Fredlund and Staff 1980b	Historic homestead	-	Historic
26	24RB392	No information	9-04-79	None	Historic homestead	NI	Historic
27	24RB393	Sandstone Chimney Homestead	4-27-80	Fredlund 1980a	Historic homestead	I	Historic
28	24RB1005	Dead Cow Site	1971	Munson and Munson 1980a	Open occupation	-	Late Plains Archaic
29	24RB1007	Lookout Point Site	1971	Munson and 1980a	Occupation/ lookout	E	Avonlea (Late pre-
30	24RB1008	Pyramid Mountain Site	1971	Munson and Munson 1980a	Open occupation/ lookout	E	Pelican Lake (Late Plains Archaic)
31	24RB1009	On-the-Way Home Site	1971	Munson and Munson 1980a	Tool manufacture/ occupation	-	
32	24RB1024	Engineer Shelter Site	1971	Munson and Munson 1980a; Fredlund and Staff 1980c	Rock Shelter with petroglyphs	E	Late Archaic?
33	24RB1040	Cow Chasing Jackson Site	12-81	Fredlund and Fredlund 1974	Open occupation	-	Late Archaic
34	24RB1054	Arrowhead Site	1973	Fredlund and Fredlund 1974	Lookout/ chipping station	-	Late Prehistoric?
35	24RB1063	Jill Site	7-23-73	Fredlund and Fredlund 1974; Fredlund 1980a; Fredlund and Staff 1980b	Lithic scatter	-	Late Prehistoric
36	24RB1068	Henley Homestead Site	1973	Fredlund and Fredlund 1974	Historic homestead	-	Historic

E = Determined Eligible
I = Determined Ineligible
- = Recommended as Ineligible by Consultant
NI = No Information

TABLE 2.13-7 (continued)

	Site Number	Site Name	Date Recorded	Report	Site Type	NRHP Eligible?	Time Period
37	24RB1070	Daughtrey Cabin Site	1973	Fredlund and Fredlund 1974	Historic homestead	NI	Historic
38	-	Charred Stump Site	12-81	None	Open occupation	NI	
39	-	Colstrip Hill Site	12-81	None	Open occupation	NI	
40	-	Red Sand Site	12-81	None	Open occupation/ lithic scatter	NI	
41	24RB868	Show Me Site	12-81	None	Open occupation	I	Late Paleo-Early Archaic

I = Determined Ineligible
NI = No Information

TABLE 2.13-8

SITES IN THE PROJECT AREA WITH POTENTIAL RELIGIOUS SIGNIFICANCE

	Site	Area	Artistic Merit	Unusual Motifs	Special Features	NRHP Eligible?
1	24RB266 (Alan's Petroglyph)	Area E	-	-	Badly eroded 1971 and 1973; disappeared by 1979	Does not appear to be eligible
2	24RB301 (Lovelace Memorial)	Buffer Zone	-	-	Both historic and prehistoric motifs	Determined ineligible
3	24RB877 (Connie's Gallery)	Area C	NI	-	Morehistoric and prehistoric motifs	Determined ineligible
4	24RB1019 (Ellison's Petroglyph)	Area A	+	+	Loss of site integrity; vandalism; motifs have been traced, photographed, cast	Determined eligible
5	24RB1024 (Engineer Shelter Site)	Buffer Zone	+	-	Obsidian date 434 A.D.; associated deposits have potential to yield significant information	Determined eligible
6	24RB871 (Sandrock Industrial)	Area D	NI	NI	Eroding, vandalism	Appears to be eligible
7	24RB302 (Petro City)	Buffer Zone	-	-	Glyphs have been traced	Determined ineligible
8	24RB875 (P.E. Davis)	Area C	NI	NI	Severe Erosion	Determined ineligible

+ = Recommended as Eligible by Consultant
- = Recommended as Ineligible by Consultant
NI = No Information

2.14 ESTHETICS

Determination of esthetic appeal is a subjective process determined by each individual's perceptions, tastes, and values. Texture, color, relief, and contrast make up most of what we see in a landscape.

At the Rosebud Mine, the texture varies from the even range grasses on gentle slopes to smooth, linear sandstone outcrops, to the jagged profile of ponderose pines on the skyline. Colors are mostly neutral: pale yellow, tans, browns, and greys, with dark greens in the timber and scattered orange, rust, and purple clinker outcrops. Relief is low to moderate, and slopes are generally broken only by the scattered sandstone or clinker ledges on the upper slopes and ridges. The most striking contrast is between the light range grass covering open slopes and the dark ponderosa pine stands along the higher ridges and divides. In cropland areas, a distinctive contrast exists between the long, straight plow rows (and subsequent linear crop lines) and the free-flowing, gradational contacts between natural vegetative types.

3.0 ANALYSIS OF IMPACTS

3.1 GEOLOGY

3.1.1 Topography/Geomorphology

The post-reclamation topography would approximate the pre-mining topography. Although the landscape would be smoother and slightly lower, the drainages and divides would be restored to their approximate pre-mine location.

The characteristics of the surficial materials (spoil and soil) anticipated after reclamation are summarized in Table 3.1-1. The characteristics of these materials, which determine erodibility, are strongly influenced by reclamation techniques.

Studies of reclaimed spoils in the Colstrip area and estimations of sediment yields under post-mining conditions (see Technical Support Document for detailed studies, Department of State Lands, Helena), suggest that yields would be moderate compared with undisturbed conditions. The highest yields can be anticipated on topsoiled spoils on which only a limited vegetation cover has developed. As vegetation cover (including root density and soil organic content) increases, sediment yields will decrease.

Other instability in the reclaimed landscape could stem from erosion at the reduced highwall and subsidence due to spoil settling. The significance of these problems is difficult to assess.

Increased infiltration along the reduced highwall may occur, possibly resulting in piping and the formation of gullies. Differential erosion rates between undisturbed bedrock and the spoils materials may also occur at the interface, which could result in modification of drainage profiles and base levels, accelerated erosion, and local diversions of drainages (See Section 3.2.2.2.3).

3.1.2 Stratigraphy

The Rosebud coal overburden would be disrupted during mining. Since the overburden has no intrinsic value, the impact of the disruption on the stratigraphy would not be significant.

3.1.3 Overburden

Western Energy proposes to use a dragline to nonselectively strip overburden. Dollhopf et al. (1978) indicate that this spoiling procedure results in large-scale mixing (producing a patchy, incomplete blend) of overburden. Dollhopf et al. indicate further that the thoroughness of mixing of inhibitory material (spoil containing constituents that might inhibit plant growth) declines as the size of the equipment used and volume of inhibitory material increase. At the Rosebud Mine, this means that pockets of essentially unmixed, undiluted inhibitory material could be preserved in the reclaimed spoils.

TABLE 3.1-1

GENERALIZED CHARACTERISTICS OF RECLAIMED LANDSCAPE

Nature of Surficial Materials	Range of Slope Gradient (%)	Vegetative Cover (%)	Drainage Density (Mi/Ml^2)	Infiltration Rate (In/hr.)	Estimated Source Area Sediment Yield ($Acre/Ft/Mi^2$)
Unconsolidated spoils material with sandy loam or loam texture. Bulk densities of 1.3 to 1.8.	Smooth rolling topography <20%. Only limited areas over 10%.	First 3 years after disturbance: 25%. 3-10 yrs. following revegetation: 70% of weeds + grass.	5-8 mi/mi^2	Highly dependent on treatment. 2-4 in/hr.	0.04
Overlain by topsoil. Low organic content (1-2%) and very little armoring.		After 10 years: 75% vegetative cover			

Note: method of calculation discussed in detail in Technical Support Document.

Table 2.1-2 shows the overburden core holes drilled by Western Energy in which overburden constituents exceed current (1977) State suspect levels. The data from core holes form the basis for predicting overburden impacts--the effects regraded overburden would have on post-mine vegetation.

Zinc and lead are not included in the table. Concentrations of these elements exceed current (1977) State suspect levels in various core increments throughout the mine area; however, the elevated values probably result from contamination by zinc- and lead-based drill-stem lubricants and not from overburden concentrations. Even if the values indicate actual overburden chemistry, no problems are anticipated. This is based on (1) several observations of revegetated areas where premining overburden drilling showed elevated levels of these and other elements and (2) state-of-the-art knowledge on overburden elemental concentrations as related to vegetative growth and uptake. In light of these recent observations and research, the Department of State Lands is updating its overburden sampling guidelines and is reconsidering the necessity of analyzing for certain elements when the overburden is alkaline.

Cadmium and manganese levels shown in the table (2.1-2) exceed current State suspect levels in a few cores; however, most of the high levels occur in volumes that make up less than 15 percent of the total core. Dollhopf et al. (1978, 1981) found that when such material constituted 5 to 15 percent of the overburden volume, the material often could not be detected in the spoil. Further, the material that was detected was generally of a lesser volume than that which was previously found, indicating partial dilution from mixing. Recent research at the Rosebud Mine indicates that if rootzone concentrations of available manganese exceed 40 parts per million after dilution, seedling development of ponderosa pine may be jeopardized (Nellie Stark, University of Montana, oral commun., November 29, 1982). Therefore, where ponderosa pine is to be reestablished, Western Energy should test the rootzone material for available manganese levels. On the other hand, where range vegetation is to be established, state-of-the-art knowledge indicates that cadmium and manganese will not disrupt reclamation, owing to the alkaline conditions typical of eastern Montana.

Nickel values exceed the current State suspect level (1.0 part per million) in many of the core increments taken throughout the Rosebud Mine area. However, in an extensive literature review, Barth et al. (1981) found that (1) nickel appears nontoxic to most animals at forage concentrations less than 1,000 parts per million (ppm); (2) available nickel concentrations of greater than 20 ppm have produced toxicity symptoms in only the more intolerant plant species; and (3) the potential for nickel toxicity appears to be greatest on poorly drained, acid soils--conditions not found at the Rosebud Mine. Munshower et al. (1978) found that Colstrip soils (undisturbed) have available nickel concentrations approaching 1 ppm and native and introduced plant species have nickel concentrations ranging from 1 to 4 ppm. The evidence suggests that nickel at the Rosebud Mine would not be toxic to post-mine vegetation. Because of this evidence, the Department of State Lands is reconsidering the necessity of analyzing for nickel in an alkaline environment.

Molybdenum concentrations frequently are found to be slightly above the current State suspect level of 0.3 ppm. However, legumes, conven-

tionally considered the most important molybdenum-accumulating plant species, are not a major component of the proposed vegetation on reclaimed sites. (Flourishes from native legume seed sources, such as yellow sweetclover, could, nonetheless, occur periodically on reclaimed land.) However, molybdenum-induced copper deficiencies (molybdenosis) are not generally expected in cattle that graze reclaimed areas.

A recent review of trace elements in mined lands (Munshower, In Press) raises some questions regarding molybdenum. Munshower suggests that the relationships between plant concentrations of molybdenum, soil molybdenum levels, and other soil properties are complex. Further, simple soil tests of molybdenum content are not likely to be of value in predicting post-mine molybdenum levels or copper/molybdenum ratios in vegetation. Thus, the procedures for assessing the potential for molybdenum problems on mined landscapes may require reevaluation.

Electrical conductivity values (salinity) are in excess of the current State suspect level in various locations throughout the Rosebud Mine area. Saline overburden placed in the rootzone can stress plants, since the salt may force plants to use more metabolic energy to take up water, and this would decrease stored food reserves. The result at the Rosebud Mine would be that small areas of sparse vegetation may occur on the reclaimed areas. Although this is unlikely, if this were to occur, Western Energy could be required to replace the saline material with a more suitable growth medium and revegetate the affected site. Such occurrences could easily be corrected since more than enough suitable soils are available for a veneer over the overburden.

Sand content values exceed the current State suspect level in many overburden core increments throughout the Rosebud Mine area. In most areas, this would probably not present any drought problems, since the cover soils would have adequate moisture-retention capacities. However, where both the surface overburden and cover soil are sandy, drought problems could occur. If areas such as these are relatively small in size, this could add to the overall plant diversity in the reclaimed areas. The less competitive warm-season grasses and forbs could establish themselves in these areas, leaving other areas for the more competitive cool-season species. Overall, sandy overburden material should not present any major reclamation problems.

All predictions of overburden impacts are generalizations. An uncertainty exists when inferences about spoils geochemistry are based on a limited number of drill cores. In a study by Dollhopf et al. (1978, 1981), in the eastern section of Area B, it was found that overburden sampling on a grid pattern with a hole density of 1,500- to 2,000-foot centers is only about 50 percent reliable in predicting the occurrence of unsuitable overburden material. However, the study points out that the results describe only the study area and have not been shown to be statistically significant for other areas. In any event, the Department of State Lands is now reviewing its guidelines regarding overburden sampling procedures and density requirements.

In summary, review of the existing overburden data suggests that regraded spoil at the Rosebud Mine would have the same overall bulk geo-

chemical characteristics as the undisturbed overburden. Localized areas of molybdenum, nickel, cadmium, and sand concentrations exceeding current State suspect levels may be created in the near-surface spoils. Near-surface electrical conductivity values across the mined areas would generally be reduced; however, small areas of increased salts could occur in the reclaimed rootzone. Present near-surface materials with high soluable salt contents (electrical conductivity) would generally be replaced at greater depths in the spoils.

3.1.4 Structure and Paleontology

There would be no foreseeable impact on the geologic structure or paleontology of the area as a result of strip mining. However, the structure, particularly the inferred faults in Area C, may have an impact on the recovery of coal in the proposed mine. Mining through a fault having a displacement of 70 feet paralleling the highwall would necessitate a discontinuous pit development in the fault area to get the pit floor down to the coal level. Such a mining procedure would probably leave one or more cuts of coal unmined and irretrievable.

3.1.5 Geologic Hazards

No major geologic hazards would result from strip mining, though some instability due to settling in the spoils would occur for a number of years after reclamation. Minor settlement has been noted in spoil areas at the existing mine. These problems include settlement cracks ranging up to 3 feet deep in a small area of newly graded but untopsoiled spoil in Area B, an area of small "sinkhole" features at the toe of a slope in a topsoiled and seeded portion of Area B, and a recent subsidence feature where spoil is settling away from the crest of a backfilled endwall. These problems have occurred within the first 3 years after regrading. The instability of the backfilled spoils may preclude construction of large structures on the reclaimed spoils until they are stabilized. Normal agricultural use of the reclaimed spoils probably would not be affected.

The proposed limitations on blasting, in terms of weight of explosive per delay charge and associated ground motion in the vicinity of structures, meets the requirements of 10 CFR 715.19. There is some evidence that the suggested (CFR) limit of 1 inch per second peak particle velocity may allow minor damage to structures, consisting of small plaster cracks or loosening of paint. The limitation on explosive weight would likely generate ground motions that are much lower than the suggested limit, based on analyses of numerous blasts at other surface coal mines. There is no evidence that this shallow blasting would cause earthquakes.

Generally, the effects of blasting on groundwater supplies adjacent to Western Energy operations are believed to be insignificant. According to one seismic study (Bond, 1975) neither groundwater flow nor quality were adversely affected. Another study conducted by Berger Associates states that aquifers show little or no effect from coal mine blasting. The report states that the maximum effects extend 140 to 160 feet from the blast hole. Water quality samples obtained after the blast were unchanged from before.

3.1.6 Resources

Mining would reduce Rosebud coal resources by 377 million tons. About 126 million tons of McKay coal would probably become irretrievable--uneconomical to mine. The Stocker seam would also be irretrievably lost. Neither the Stocker nor the McKay would ever, in all likelihood, become more economic to mine than at the time of mining the overlying Rosebud seam.

3.1.7 Mitigation

Because of the increase in trace metal content in the 5 to 10 feet of shale lying directly above the Rosebud coal in much of the proposed mine area, some method of selective removal of that zone in stripping overburden might be considered. A method that would prevent mixing that zone with other spoils and keep it below the top 10 feet of reclaimed spoils would minimize and, in many cases, eliminate elevated nickel, cadmium, and molybdenum values in the near-surface spoils. Possible methods include loading and hauling this material for later selective placement in the spoils or selective dumping of this material with the dragline to ensure it does not end up on top of the spoils pile. The latter method would be more economical and probably easily achievable.

Field mapping could determine whether significant faulting, where now inferred, exists in the mine area. If present, such faulting should be incorporated into Western Energy's mine plan. Planning that recognizes significant faulting could improve coal recovery.

Settlement can be mitigated with bulldozer grading. Future subsidence problems will probably be small (under 4 feet of vertical displacement), mitigatable by backfilling and regrading and will occur soon after spoil grading. Subsidence problems are expected to be evident well before the end of the 10-year bonding period.

Dr. Nellie Stark (University of Montana, oral commun., November 29, 1982), recently found that where manganese concentrations are in excess of 40 parts per million in the rootzone of ponderosa pine at the Rosebud Mine, seedling development could be jeopardized. Therefore, in areas where ponderosa pine is to be reestablished, Western Energy could test the rootzone soils for available manganese.

3.2 HYDROLOGY

Sections 3.2.1 and 3.2.2 examine the anticipated hydrologic impacts from mining in Rosebud Mine Areas A, B, C, D, and E (Fig. 2.2-3). The cumulative impacts on groundwater and surface water use, flow and quality from mine-related development, and the nearby Big Sky Mine are examined in Section 3.2.3. If no impact or minimal impact is anticipated at a particular location or through a particular time frame, neither the location nor the time frame are discussed. Table 3.2-1 is a listing of drainage basins included in the analysis. Impacts anticipated are noted in this table. Mitigation measures are discussed in Section 3.2.4.

The groundwater, surface water, and cumulative hydrologic impacts sections are divided into two time periods: (1) the next 5 years (impacts through 1987) and (2) for 100 years beyond 2017. Selected mitigation measures to reduce hydrologic impacts are also discussed in this section.

3.2.1 Groundwater

This section addresses the influence mining activities would have on the quantity and quality of groundwater, either originating in or flowing through the hydrologic study area. It must be determined if (1) aquifers or (2) groundwater discharge to surface water would be depleted or contaminated by mining. (For groundwater mitigations, refer to Section 3.2.4.)

3.2.1.1 Impacts through 1987

3.2.1.1.1 Groundwater Flow

Mining at the Rosebud Mine will change the hydraulic properties of near-surface aquifers. The Rosebud overburden would be broken and mixed up as it is placed back into the preceding mine pit. The replaced overburden (spoils) will have about the same horizontal conductivity as the pre-mining strata. However, as a result of mixing and rubblizing of the overburden, the vertical hydraulic conductivity values will increase significantly from pre-mining values (Van Voast et al., 1977). The higher vertical conductivity will increase the potential for post-mining groundwater recharge; however, other factors, such as vegetative consumption of precipitation, will also determine post-mining recharge rates. As such, it will be difficult to predict exactly where and how much groundwater recharge will change. (See Recharge and Discharge Relationships.)

The overall porosity of the backfilled material will be greater than that of the Rosebud coal seam. The post-mining increase in effective porosity will allow increased groundwater storage.

Groundwater Movement in Water-Bearing Strata

A regional, three-dimensional computer model was made of the hydrologic study area. The modeled geology consisted of multiple thickness of

TABLE 3.2-1

ANTICIPATED HYDROLOGIC IMPACTS IN THE COLSTRIP AREA ASSOCIATED WITH COAL MINING AND MINING-RELATED ACTIVITIES

Drainage	Alluvial Groundwater Flow (4)	Surface Water Flow	Alluvial Groundwater Quality (5)	Surface Water Quality	Sedimentation/ Erosion	Major Contributing Factor
East Fork Armells Creek -Upstream of Colstrip	Insignificant Change	Slight Reduction in Peak and Total Flow	Worse	Slightly Worse	Decrease	Rosebud Mine
-Downstream of Colstrip	Detectable Increase	Significant Increase During Low Flow Periods	Worse	Slightly Worse	Decrease	Rosebud Mine & Industrial Ponds
Stocker Creek	Insignificant Change	Slight Reduction in Peak and Total Flow	Worse Near Headwaters; No Change Downstream	No Expected Change	Slight Decrease	Area C, Rosebud Mine
Pony Creek (Downstream of Area D)	Insignificant Change	Slight Reduction in Peak and Total Flow	Very Small Increase (less than 5%)	Slightly Worse	Decrease	Area D, Rosebud Mine
Cow Creek -Headwaters	Increase	Slight Reudction in Peak and Total Flow	Worse	Slightly Worse	Decrease	Rosebud Mine & Power Units 1,2,3 & 4
-Middle and Lower Reaches (Below Spreader Dikes)	Minimal Increase	Minimal Change	Negligable Change to Detectably Worse (Up to 25% Increase)	No Change	Slight Decrease	Rosebud Mine & Power Units 1,2,3 & 4 Industrial Ponds
South Fork Cow Creek	Insignificant Change	Slight Reduction in Peak and Total Flow	Worse	Minimal Change	No Expected Change	Rosebud Mine
Hay Coulees	Insignificant(1) Change	Slight Reduction in Peak and Total Flow	Worse	Unknown	No Change	Pit 6, Rosebud Mine
Coal Bank Coulee	Insignificant(1) Change	Slight Reduction in Peak and Total Flow	Worse	Slightly Worse	Decrease	Areas B & C, Rosebud Mine & Big Sky Mine

(Continued)

TABLE 3.2-1 (Continued)

ANTICIPATED HYDROLOGIC IMPACTS IN THE COLSTRIP AREA ASSOCIATED
WITH COAL MINING AND MINING-RELATED ACTIVITIES

Drainage	Alluvial Groundwater Flow (4)	Surface Water Flow	Alluvial Groundwater Quality (5)	Surface Water Quality	Sedimentation/ Erosion	Major Contributing Factor
Miller Coulee	Insignificant(1) Change	Slight Reduction in Peak and Total Flow	Worse	Worse	Decrease	Areas B & C, Rosebud Mine & Big Sky Mine
Lee Coulee	Insignificant(2) Change	Slight Reduction in Peak and Total Flow	Worse	Unknown(2)	No Change	Areas B & C, Rosebud Mine & Big Sky Mine
Richard Coulee	Unknown	Slight Reduction in Peak and Total Flow	Unknown(3)	Unknown(2)	Unknown(2)	Rosebud Mine & Big Sky Mine
Rosebud Coulee	Insignificant Change	No Measurable Change	No Expected Change	No Expected Change	No Measurable Change	Rosebud Mine & Big Sky Mine

(1) Data inconclusive because no baseline information exists for comparison.
(2) Data inconclusive. No submitted mine plan from Peabody Coal Company.
(3) Unknown because of lack of background groundwater quality.
(4) See Table 3.2.3 for quantification and discharge changes that could occur in each of the drainages.
(5) Number within brackets indicates probable increase in total dissolved solid levels that mining of the Rosebud Mine would cause (rounded to nearest 5%).

geologic strata with variable hydraulic properties. Surface water drainages were also a parameter in the groundwater computer model. The model predicts groundwater flow changes that result from mining. The flow model has limitations:

- o It is regional, and not site-specific, and includes assumptions on regional aquifer properties.

- o It was calibrated using only known stresses. Stresses that are unknown, such as for the proposed fly ash ponds, were not included. Nor were groundwater flow stresses included that were considered insignificant compared to the regional flow system, such as the existing fly ash pond leakage (21 acre-feet/year).

The modeling effort is an estimate of how the regional groundwater flow system will react to mining. The model includes changes in the groundwater system as existing pits are backfilled, while new pits are opened, causing localized lowering of water levels. Because aquifer characteristics input to the model were based on limited data, it is not always possible to accurately predict changes in a complex aquifer system. Thus, the aquifers may respond differently than predicted. If significant regional variation in the flow system is observed during mining, the study area should be reexamined and remodeled.

Table 3.2-2 and Figures 3.2-1 through 3.2-3 present the modeled drawdown at various distances from pit centers for each mine area at various times. It can be seen that drawdown is usually small at a distance of 2,000 feet for any given year. The table and figures represent the ranges of "worse case" results obtained by flow modeling for each mine area.

The only water-bearing units of importance that would be affected by mining are the Rosebud overburden and the Rosebud coal. Although the Rosebud-McKay interburden would be affected, the effects will be localized. (See 3.2.1.1.2, Rosebud/McKay Interburden).

Recharge/Discharge Relationships:

The impacts to be addressed are (1) impairment to aquifers during mining and, (2) changes in the rates of groundwater discharge to nearby drainages that would diminish surface water flow.

Drawdown caused by opening mine pits would temporarily affect groundwater discharges to nearby alluvial groundwater systems. A majority of East Fork Armells Creek above Colstrip receives groundwater (bedrock) discharge, as do the coulees tributary to Rosebud Creek farther south. Table 3.2-3 shows a comparison, based upon results of flow modeling, of changes in groundwater discharge rates for each drainage area between 1983 (existing development) and 2118. The results show that only small changes for drainages are expected through 1987. The mine pits would locally dewater the near surface aquifers, decreasing discharges to these drainages. Once the mine pits are backfilled, groundwater discharges would return to nearly pre-mine condition. (See Section 3.2.1.2.)

TABLE 3.2-2

DRAWDOWN EFFECTS OF MINING ROSEBUD OVERBURDEN
AND ROSEBUD COAL SEAM,
(in vertical feet)
ROSEBUD MINE AREA, MONTANA

Rosebud Mine Area	Year	0[2]	2,000	4,000	6,000
A	1983	M	NP	NP	NP
	1984	30	2-3	0.0-1.0	0
	1985	26	4-6	0.5-1.0	0
	1986	23	5-10	1.0-2.0	0
	1987	22	5-10	2-3	5-10
	2017	12	5-10	5-10	5-10
	2118	1	0-1	0-1.5	-2-2
B	1983	M	NP	NP	NP
	1984*	80	10-15	1.5-2.0	0.0-1.0
	1985	64	2-4	0.0-1.0	0
	1986	56	4-6	1-2	0.0-1.0
	1987	50	45-50	10-15	2-4
	2017	42	40-46	36-46	17-46
	2118	24	23-25	21-26	19-26
C	1983	50	4-6	0.5-1.0	0
	1984	72	2-5	0.5-1.0	0
	1986	72	5-10	1-3	0.0-1.0
	1987	72	5-10	3-4	0
	2017	82	15-70	8-60	3-45
	2118	30	27-32	23-35	NP
D	1983	M	NP	NP	NP
	1984	46	20-25	0-0.2	0
	1985	34	15-20	1.0-2.0	0
	1986	28	15-20	2-3	0.0-1.0
	1987	24	15-20	3.0-4.0	0.0-1.0
	2017	4	2-6	2-6	4-10
	2118	-4[1]	-1-5	-0.5-7.0	0-8
E	1983	M	NP	NP	NP
	1984	55	50-55	5-7	0.5-0.9
	1985	45	40-45	5-10	1.0-2.0
	1986	40	35-40	10-15	2.0-3.0
	1987	35	30-35	10-15	3.0-5.0
	2017	15	12-18	10-23	6-27
	2118	0	-1-2	5-4.5	8-6
Big Sky Mine	1983	25	4-6	0.0-1.0	0
	1984*	24	4-6	0.0-2.0	0.0-1.0
	1985	23	5-10	1.0-3.0	0.0-1.0
	1986	22	5-10	2.0-3.0	0.0-2.0
	1987	20	5-10	2.0-4.0	1-3
	2017	15	12-18	10-23	6-27
	2118	0	-1-2	5-4.5	8-6

M - Mined (aquifer has been affected by mining)
NP - Not Predicted
* Combined effect from Western Energy and Peabody Coal Company operations
[1] Negative values indicate levels exceeding pre-mining conditions
[2] Radial distance from approximate mine area center

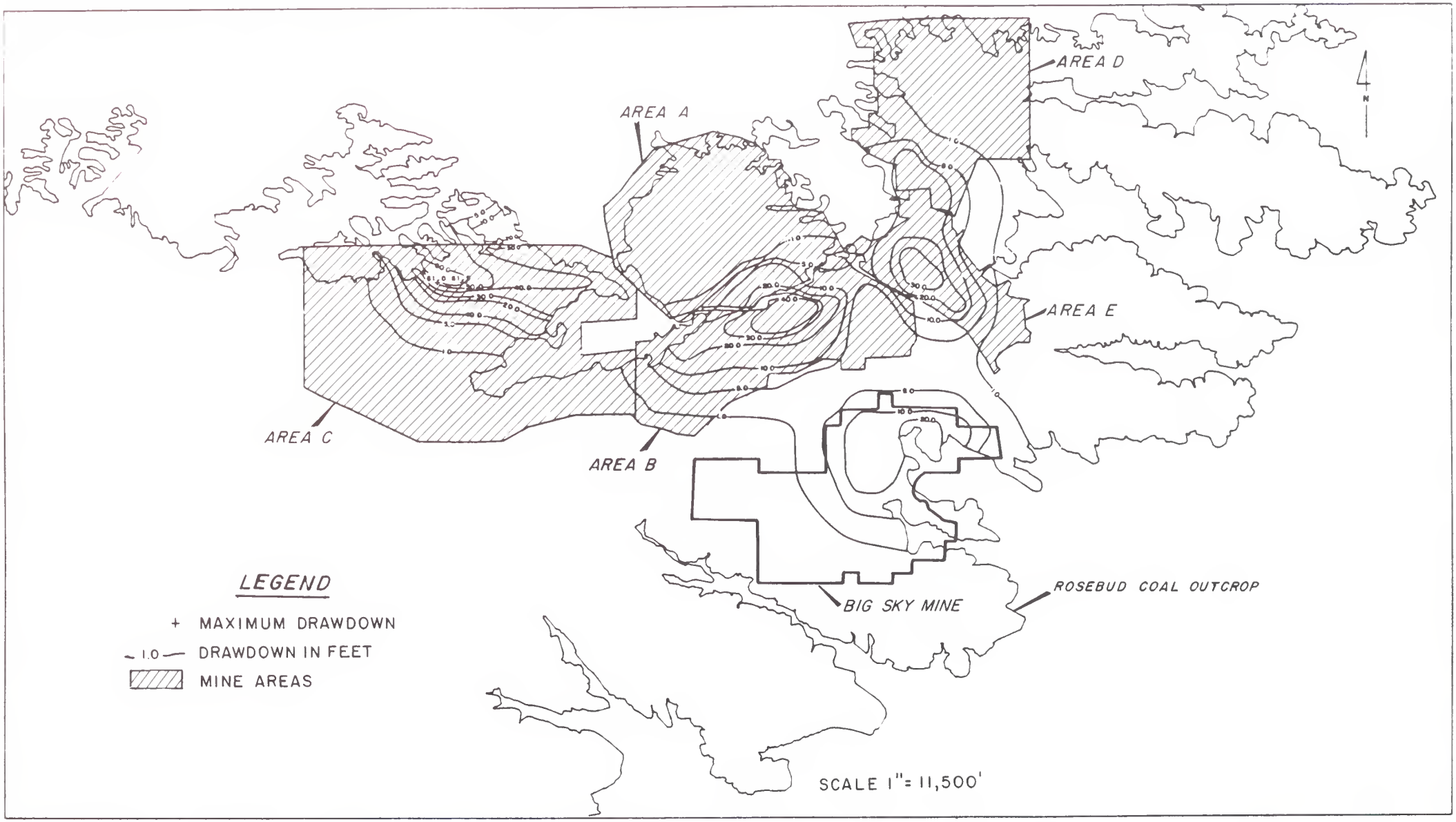


FIGURE 3.2-1 PREDICTED DRAWDOWN, ROSEBUD COAL AQUIFER, YEAR 1988, ROSEBUD MINE AREA, MONTANA

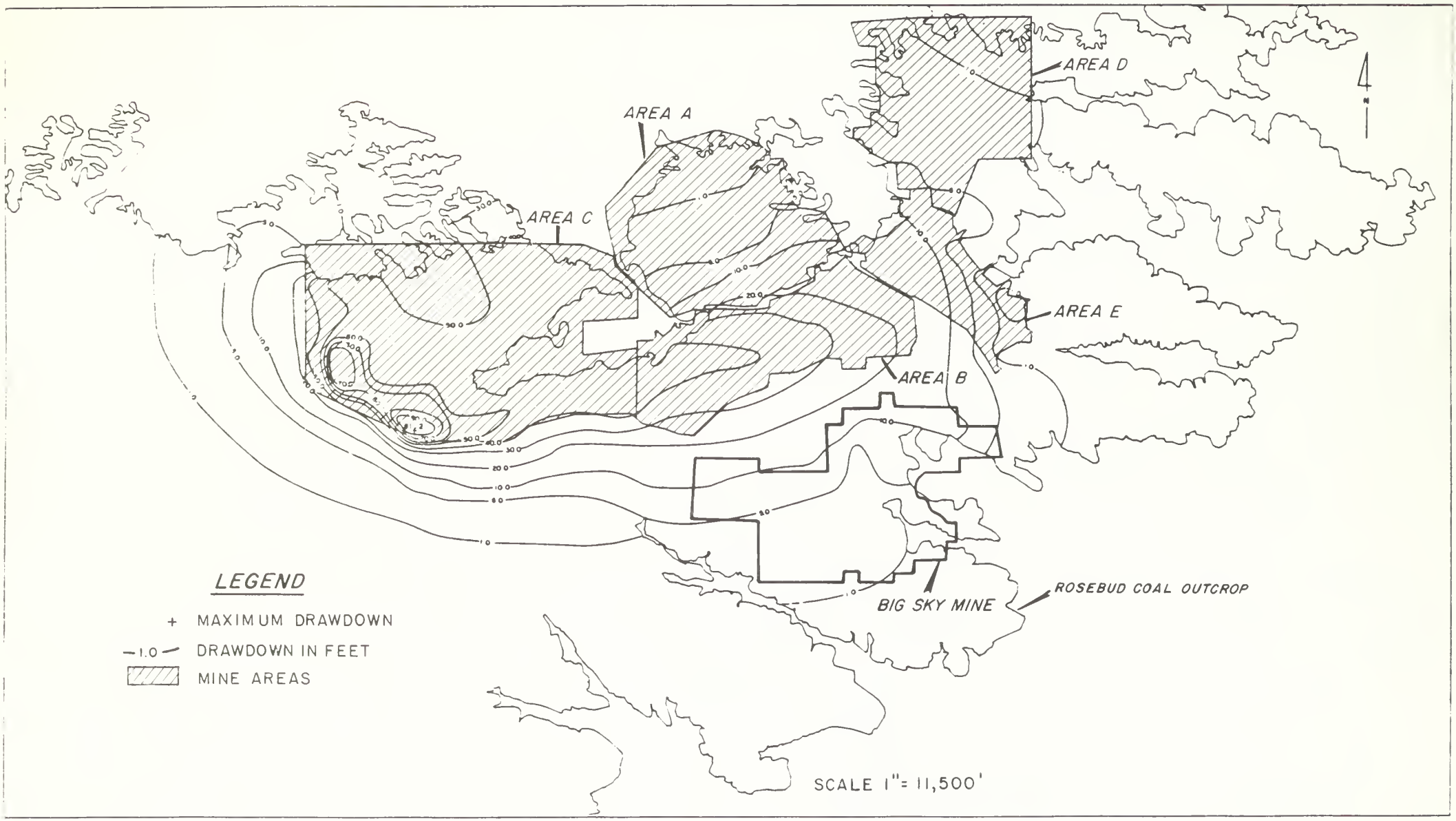


FIGURE 3.2-2 PREDICTED DRAWDOWN, ROSEBUD COAL AQUIFER, YEAR 2018, ROSEBUD MINE AREA, MONTANA

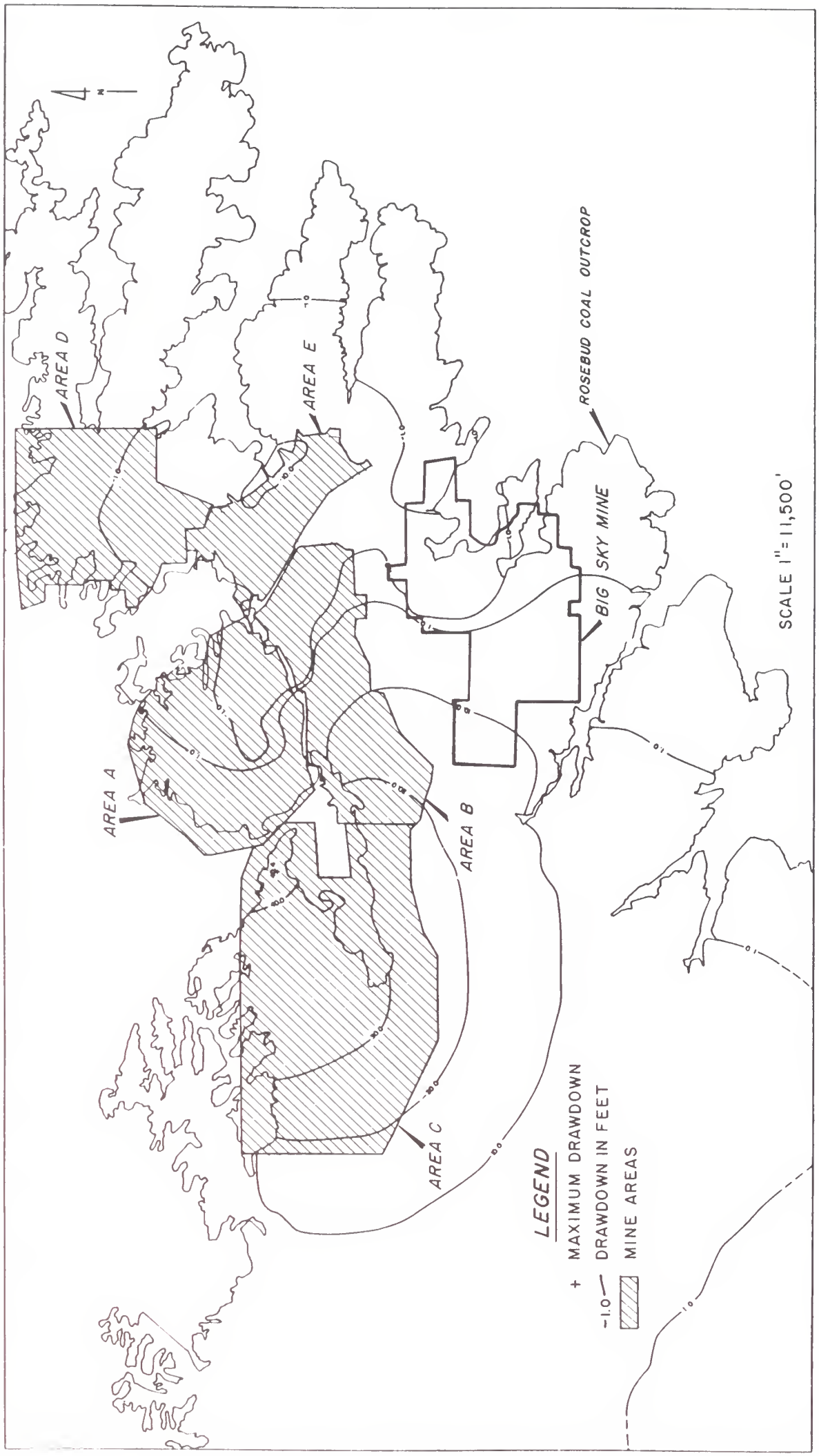


FIGURE 3.2-3 PREDICTED DRAWDOWN, ROSEBUD COAL AQUIFER, YEAR 2118, ROSEBUD MINE AREA, MONTANA

Groundwater/Surface Water Relationships

The discharges in Table 3.2-3 were computed by summing groundwater discharges (per computer node) along each drainage, as calculated by the flow model. By subtracting discharges between any two years, the maximum change in flow was estimated. Because the flow rates (130 acre-feet/year) for the Rosebud seam that were used in the model were higher than the average value reported at the Rosebud Mine, the estimated changes in discharge to streams are likely worst-case values.

If recharge of groundwater is actually greater after mining, then groundwater discharges to nearby drainages would also increase after mining (Table 3.2-2). Under these conditions, the changes in discharge between 1983 and 2118 are relatively small, except for Miller Coulee and Coal Bank Coulee, which could experience slight to moderate increases in bedrock discharge over the next 100 years. Because pre-mine flow data were estimated for both coulees, these large changes may not represent the level of increase that could occur.

The small predicted changes in bedrock discharge, whether slightly more or less, probably would not significantly affect the hydrologic systems of the receiving drainages. Bedrock discharges generally make up only a part of the recharge to alluvial groundwater flows, and changes in alluvial groundwater levels would likely be offset by changes in evapotranspiration within the alluvial system. The only drainages that are predicted to experience significant changes are south and east of the Big Sky Mine: Coal Bank and Miller Coulees. Although the modeled discharges for these drainages are significant, the estimates were calculated using data from hydrologically similar drainages. Baseline data is not available for Coal Bank and Miller Coulees.

3.2.1.1.2 Groundwater Quality

Spoils

Within mined areas, the Rosebud overburden and Rosbud coal seam will be replaced by spoils. Upgradient groundwater will flow into the spoils, resaturating the bottom portion. Following resaturation, pre-mining flow patterns will be restablished, and spoils waters will move out of the mined area and enter undisturbed bedrock and/or alluvium.

Changes in groundwater quality will occur as the groundwater passes through the mine spoils. Overburden strata contain soluble salts, which are available for solution by the water moving through the spoils. The solution process will increase TDS levels of waters in the mine spoils. As a result alluvial and bedrock groundwater in areas downgradient from mine areas will eventually have higher TDS levels.

To estimate the quality of Rosebud spoils water, a relationship was established between electrical conductivity of extracts from the Rosebud overburden and actual TDS values for spoils groundwater located in Areas A, B, and E. The method has previously been used by Van Voast (1978) and Western Energy and their consultants.

TABLE 3.2-3

GROUNDWATER DISCHARGE*
MINING MODELS IMPACTS TO SURFACE DRAINAGE
(acre-feet per year)

Drainage Area	1983	1987	%*	2017	%*	2118	%*
Pony Creek	71.2	71.2	0	71.2	0	71.5	0.4
Cow Creek	121.0	116.8	-3.4	121.3	0.3	122.9	1.6
South Fork Cow Creek	10.4	10.4	0	10.4	0	10.7	2.9
Unnamed Coulee	31.3	31.3	0	31.3	0	31.6	1.0
Hay Coulee**	--	38.5	--	39.2	--	41.1	--
Coal Bank Coulee**	--	12.8	--	16.4	--	21.2	--
Miller Coulee**	--	38.3	--	40.2	--	43.7	--
Lee Coulee**	--	63.3	--	65.3	--	68.4	--
Richard Coulee	88.6	88.6	0	88.3	-0.3	87.3	1.5
Rosebud Creek	278.1	278.1	0	278.2	0	270.8	-2.6
Rosebud Drainage	600.6	749.3	--	761.8	--	769.2	--
East Fork Armells Creek*	141.3	138.8	-1.8	131.1	-7.2	146.0	3.3
Stocker Creek	181.4	180.3	-0.6	169.6	-6.5	169.0	-6.8
East Fork Armells Creek/Stocker Creek Drainage	322.7	319.1	-1.1	300.7	-7.3	315.0	-2.4
Total	923.3	1,068.4	--	1,062.5	--	1,084.2	--

* % change from 1983 discharge amount.

** data inconclusive because no baseline data exist for comparison.

TDS values were calculated for 26 bore hole extract composite electrical conductivity (EC) values in Area C. TDS values obtained ranged from 1,600 to 8,800 mg/l. The highest TDS values occurred where the ratio of shale and clay to sand in Rosebud overburden material is highest. The average calculated TDS values for spoils water in Sections 1, 2, and 3 (from east to west) in Area C are 2,400, 2,500, and 5,200 mg/l, respectively, and compare favorably to measured TDS values from spoils wells in Areas A, B, and E, which range from 1,700 to 5,000 mg/l.

Based upon data from recently mined areas at the Rosebud mine, spoils groundwater quality is generally 50 to 130 percent more saline than pre-mining groundwater. (See Chapter II, Section 2.2.1.3.2) The average TDS level of the Rosebud spoils is 2,900 mg/l, the Rosebud coal averages 1,890 mg/l; and the Rosebud overburden averages 1,250 mg/l.

TDS levels of mine spoils could be even higher once spoils water from one area passes through additional mine spoils located downgradient. It is estimated that over the life of the mine the maximum mean TDS concentrations in spoil material could reach 4,500 to 5,000 mg/l at the Rosebud Mine (personal commun., Van Voast, 1982).

Even at these higher levels, spoils water could be used for watering most livestock (see Chapter II, Section 2.2.1.3.1), the primary pre-mining and projected post-mining groundwater use at the Rosebud Mine area. Spoils water would not be suitable for irrigation or domestic water supplies. Deeper aquifers could be used for domestic supplies, should the need arise. (See Water Use.)

Valley Fill

Over time, mining will cause the water quality of valley fill material adjacent to spoils to deteriorate (refer to Table 3.2-1).

Waters discharging from existing spoils aquifers would continue to recharge the adjacent valley fill of East Fork Armells Creek and Stocker Creek. The TDS concentration in the valley fill of East Fork Armells Creek now ranges from 1,300 to 3,000 mg/l in areas unaffected by existing mine spoils. Increases in TDS levels (to 3,000 to 5,000 mg/l) of East Fork Armells Creek alluvium are already occurring locally in valley fill adjacent to the spoils in Areas A and B. This effect will be more widespread in the future. The TDS increases in the Armells Creek alluvium would not significantly affect agricultural uses of the groundwater. Bedrock discharges and some manmade discharges to the alluvium at and below Colstrip would continue to dilute increases in TDS related to coal mining (See Chapter II, Table 2.2-2 and Section 2.2.3, Cumulative Hydrologic Impacts.)

There will be no impact to the Stocker Creek drainage basin because there will be no mining in this part of Area C prior to 1987.

Previous mining is suspected of already increasing TDS of water in the alluvium of the headwaters of Cow Creek and South Fork Cow Creek. (See

Figure 2.2-13, Table 3.2-4 and the discussion in Section 2.2.1.3.1, Valley Fill Aquifer.) As an example, the measured TDS values for wells WA-144 and WA-145 (located just upstream of well WA-135, Figure 2.2-13) are estimated to be from 5 percent up to 25 percent higher than if mining had not occurred. (See Table 3.2-1) The existing alluvial groundwater quality at these wells averages 4,990 mg/l; water this high is unfit for irrigation and domestic water supplies (McKee and Wolf, 1974).

The primary effect of spoils water on these two drainages may be to reduce the vegetative productivity along the creek bottom in the headwaters where alluvial groundwater surfaces.

Ponding of alluvial groundwater near the headwaters of the two creeks for watering cattle or horses is not recommended. Evaporation of water would tend to further concentrate salts, possibly harming livestock. Water from the sub-McKay is available if additional water sources are needed.

Previous mining has not changed, nor is it expected to noticeably change, the alluvial groundwater quality of Cow Creek or South Fork Cow Creek at or below the middle reach. Montana Power Company completed three alluvial wells just downstream from the spreader dikes on Cow Creek at the eastern edge of section 32, T. 2 N., R. 42 E. Total alluvial flow at these wells was 120 to 200 gpm. Spoils water from Area E (2-5 gpm) would be diluted to undetectable levels by the large alluvial groundwater flows.

Similarly, the impacts to the alluvial groundwater in the lower reaches of South Fork Cow Creek would be diluted to undetectable levels.

Rosebud Coal

The Rosebud coal aquifer will be removed from most of the Rosebud Mine area. Small areas of coal will be left during mining, such as beneath the sandstone ridge in Area C. Once the adjoining areas are backfilled and the groundwater flow patterns are reestablished, the better quality water in the coal will mix with the spoils water.

Rosebud/McKay Interburden

Throughout most of the mine area the spoils aquifer is in direct contact with the Rosebud/McKay interburden. Mixing of spoil and interburden water could occur where vertical flow is caused by differences in potentiometric heads. Spoils water would move down into the interburden in areas where the potential water levels in the interburden are lower than that in the spoils.

Downward migration of spoils water is limited in areas where shale, a less permeable bed (aquitard), is the predominant interburden material. However, in most of Area C, the south side of Area A, and in Area E, the interburden is composed mostly of sandstone. In such places, spoils water would pass more readily through the interburden, and the TDS of the interburden water would be increased by a moderate amount.

TABLE 3.2-4

Cow Creek Valley Fill Water Quality[1]

Station	Cond[2]	TDS
WA-145	4890	4910
WA-144	5080	5170
WA-142	4905	5020
WA-135	4181	4850
WA-134	2730	2980
WA-133	3960	3930
WA-132	3170	2590
557-A	2820	2540
559-A	3090	2820
558-A	3020	2770

1. All values are in milligrams/liter unless otherwise specified.

2. Conductivity in M mohs/cm.

Because the interburden is not a water source, the change in groundwater quality in itself is not significant. But groundwater in the interburden will most likely discharge to surface drainages. (See Section 3.2.3.)

Deeper Aquifers

Generally, the deeper McKay coal and sub-McKay aquifers will not be significantly affected by mining in the next 5 years. In some areas a small amount of spoils water could move into the deeper aquifer, but, because of dilution, the water would still be suitable for stockwatering after mining.

3.2.1.1.3 Water Use

Consumptive uses of water at the Rosebud Mine complex are livestock watering and dust suppresion by Western Energy. As discussed in Section 2.2.1.3.1, water now used for stock cannot be used to its greatest efficiency, because of the existing poor quality. Neither spoils water nor alluvial groundwater is or would be suitable for irrigation.

Ongoing mining activity will result in an increase in TDS concentrations in valley fill adjacent to mined areas, and would lower water quality in valley fill material in East Fork Armells Creek and Stocker Creek, making it slightly less suitable for stock watering than at present. However, the water would still be within the limits of the stock water quality criteria presented in Section 2.2.

Mining will destroy most existing wells and springs within the mine areas, which may affect present and future groundwater uses. Mining will also cause drawdown at several wells outside the immediate mine areas. The dewatering effects of mining can cause a drawdown of the potentiometric surface out to about 1 mile. Most of the wells would still produce water, but the depth to water would be greater. Table 3.2-5 lists the wells and springs that would be effected by mine related drawdown. The table also shows the maximum possible drawdown throughout the life of the mine for the affected wells and springs. It should be noted that some of the wells and springs in this list may no longer exist or may no longer be in use.

Water wells and developed springs destroyed by mining will most likely be replaced by wells completed in the sub-McKay aquifer. Generally, Rosebud coal and overburden wells replaced by sub-McKay wells will produce slightly poorer quality water. Sub-McKay wells that replace valley fill and McKay coal wells will produce slightly better quality water.

Twelve wells and four springs (Table 3.2-5) not destroyed by mining would experience declines in water levels. The water level will not dry up the wells, but pumping costs will increase as a result of the pump having to lift water from a greater depth. It is possible that the effect of drawdown will be either to diminish flow or to dry up these springs.

TABLE 3.2-5

WELLS AND SPRINGS AFFECTED BY MINING
(LIFE OF MINE)
ROSEBUD AND BIG SKY MINES
ROSEBUD COUNTY, MONTANA

Area	Well or Spring Designation	Distance from Pit[4] (in feet)	Maximum Estimated Drawdown (in feet)
A	PW-25[1]	0-2000	8-13
	W.R. #42KJ-W-039569-00[2]	0-2000	12-17
	(none)	2000-4000	
	(none)	4000-6000	
B	PW-41[1]	0-2000	28-33
	W.R. #42KJ-W-039568-00[2]	0-2000	28-33
	W.R. #42KJ-W-039570-00[2]	0-2000	28-33
	PW-40[1]	2000-4000	20-25
	PW-42[3]	2000-4000	10-15
	W.R. #42KJ-C-015835-00[3]	2000-4000	24-29
	PW-39[1]	4000-6000	9-14
	W.R. #42KJ-C-000589-00[3]	4000-6000	3-8
	W.R. #42KJ-C-000872-00[3]	4000-6000	10-15
	SP-06[3]	4000-6000	5-10
C	PW-03[1]	0-2000	20-25
	PW-04[1]	0-2000	5-10
	PW-31[1]	0-2000	20-25
	SP-02[1]	0-2000	15-20
	SP-19[1]	0-2000	25-30
	SP-20[3]	0-2000	25-30
	PW-32[2]	2000-4000	0-5
	SP-01[1]	2000-4000	5-10
	PW-19[3]	4000-6000	0-5
D	(none)	0-2000	
	(none)	2000-4000	
	W.R. #42A-W-034885-00[3]	4000-6000	0-5
	W.R. #42A-C-000871-00[3]	4000-6000	0-5
	SP-16[3]	4000-6000	0-5
E	(none)	0-2000	--
	(none)	2000-4000	--
	SP-13[3]	4000-6000	7-12

TABLE 3.2-5 (Continued)

Area	Well or Spring Designation	Distance from Pit (in feet)	Maximum Estimated Drawdown (in feet)
Big Sky Mine	(none)	0-2000	--
	PW-45[3]	2000-4000	0-5
	W.R. #42A-C-005968-00[3]	2000-4000	0-5
	W.R. #42A-C-005969-00[3]	2000-4000	2-7
	W.R. #42A-C-008398-00[3]	2000-4000	0-5
	W.R. #42A-W-027336-00[3]	4000-6000	0-5

[1]Will be destroyed prior to 1987.

[2]Will be destroyed post-1987.

[3]Indicates a well or spring that will not be removed by mining.

[4]Three radii (2,000, 4,000 and 6,000 feet) were drawn from a point within each pit that would be mined for the year of the greatest effect due to mining (greatest drawdown).

Note: Private wells without water rights designations are numbered as PW; those wells with water rights designations are WR; and developed springs are designated as SP. See Plate B-2 in Technical Support Document for location of wells and springs.

The following summarizes, in a general way, the magnitude of pumping cost increases that may occur where a well has an original static water level of 150 feet, the wire-to-water efficiency is maintained at 0.5, and desired discharge is fixed (Anderson, 1979).

Decline in Water Level (in feet)	Kilowatt Hours per 1,000 gallons	Electrical Pumping Costs (in cents per 1,000 gallons)
0	0.942	7.0654
10	1.005	7.54
20	1.07	8.03
30	1.13	8.48

If a value for electrical power of 7.5 cents/kWh is assumed (personal commun., Intermountain Rural Electrical Association), an increase in pumping costs of about 1.5 cents per 1,000 gallons would occur if water levels were drawn down by 30 feet. For the average water user with a 10-gpm well pumping continuously, the change would be $6.50 per month, or $78 per year. Because most wells are not pumped continuously, the actual cost would be less.

If a spring is disturbed or affected by mining, and if a future water supply is required to sustain the existing or future land uses, the company would be required to replace the supply.

Water Quality - Other Aquifers

None of these lower aquifers would be changed sufficiently to affect their present or future uses.

3.2.1.2 Impacts in the Rosebud Mine Area through the Life of the Mine and 100 Years Beyond

This section addresses the influences that existing and proposed mining activities would have on the regional groundwater system in the Rosebud Mine area during the life of the mine and 100 years after mining. The anticipated long-term mining impacts have been predicted by modeling the regional hydrologic system.

3.2.1.2.1 Groundwater Flow

Impacts to Mine Area Potentiometric Levels

Table 3.2-2 and Figures 3.2-1 through 3.2-3 show the maximum predicted drawdown for the years 1987, 2017, and 2118. Figures 3.2-4 through 3.2-9 are time-drawdown plots for the Rosebud coal for a central point in the various mine areas. The values have been taken from the 0 radius column in Table 3.2-2.

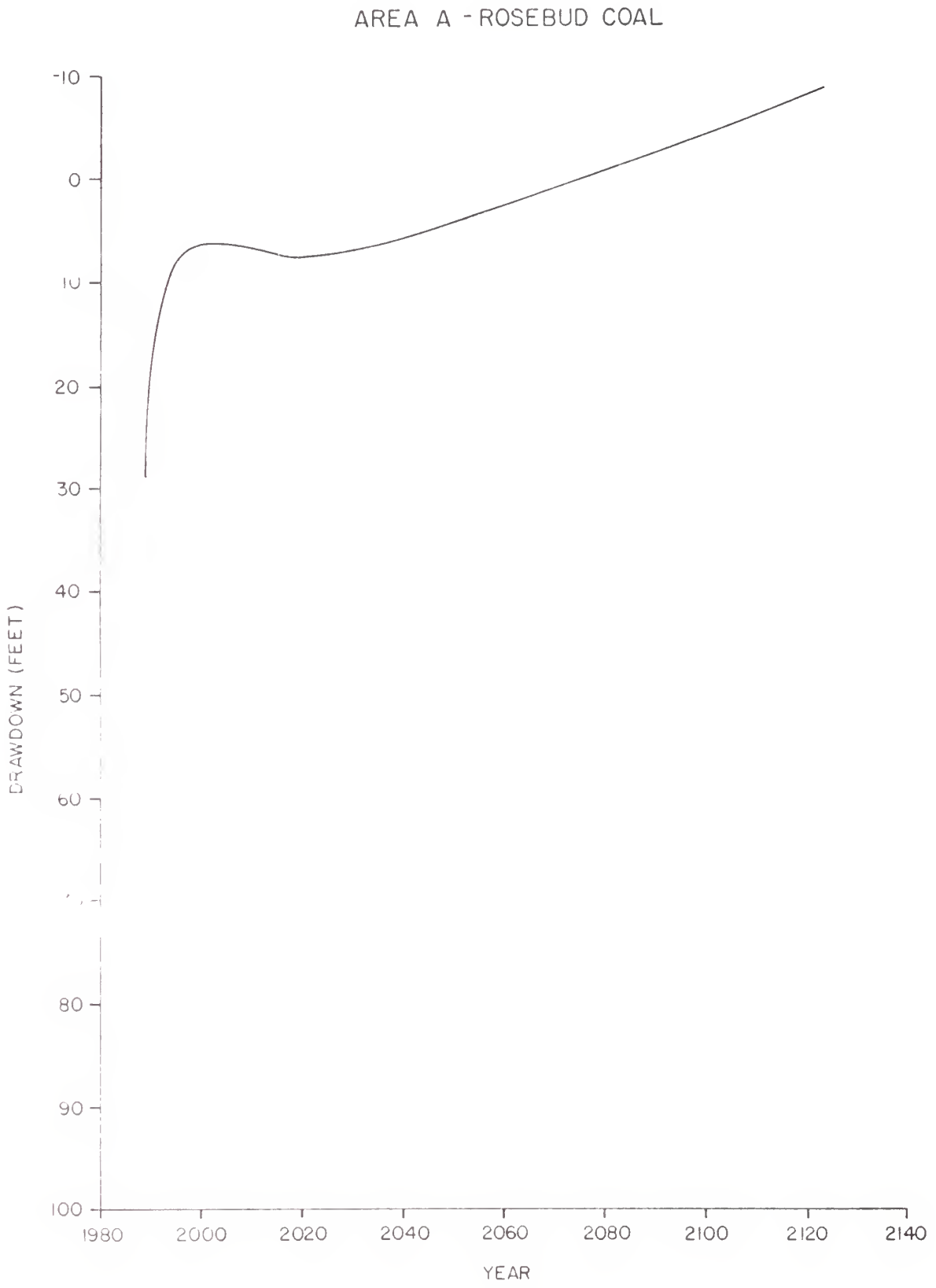


FIGURE 3.2-4 TIME - DRAWDOWN PLOT, AREA A

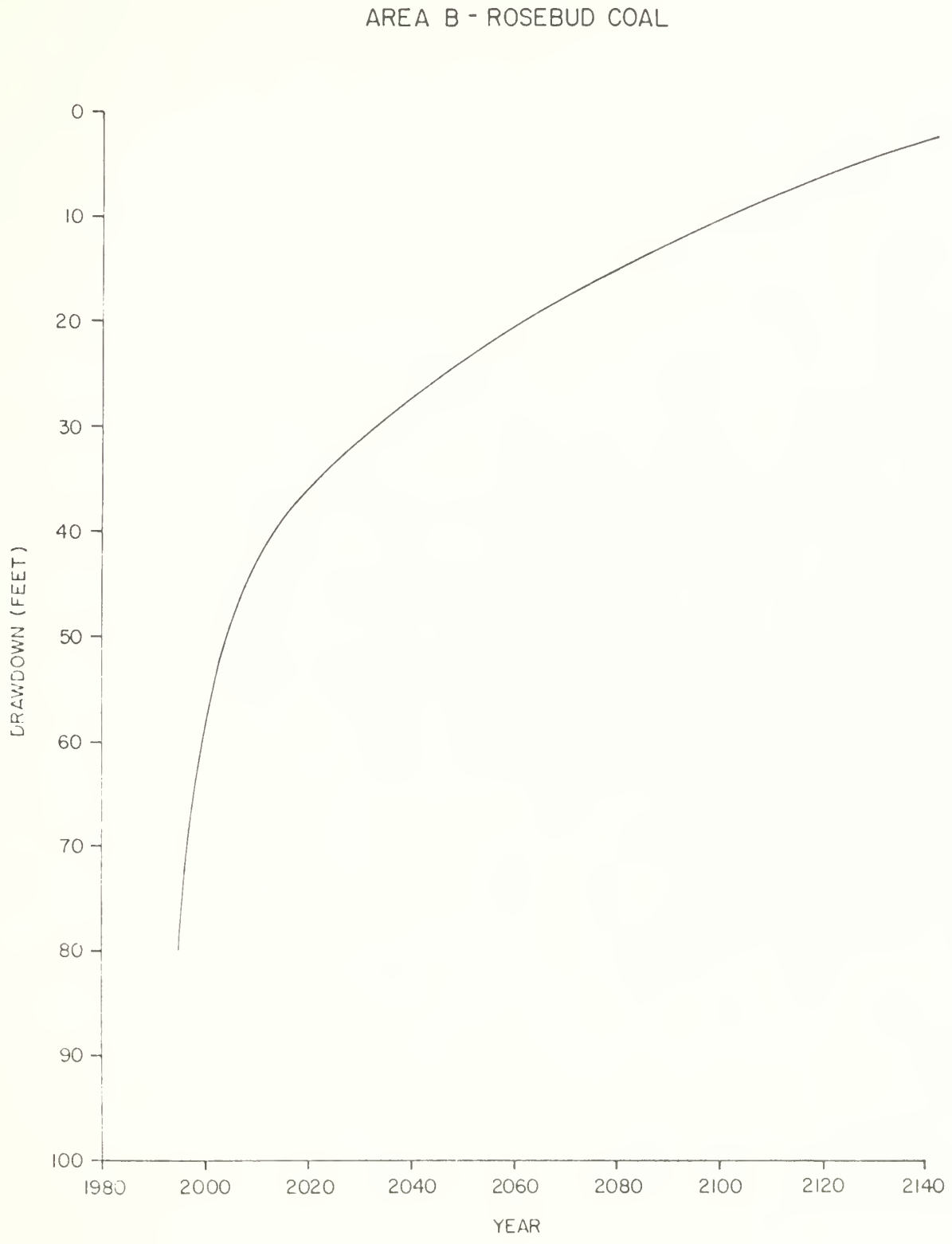


FIGURE 3.2-5 TIME - DRAWDOWN PLOT, AREA B

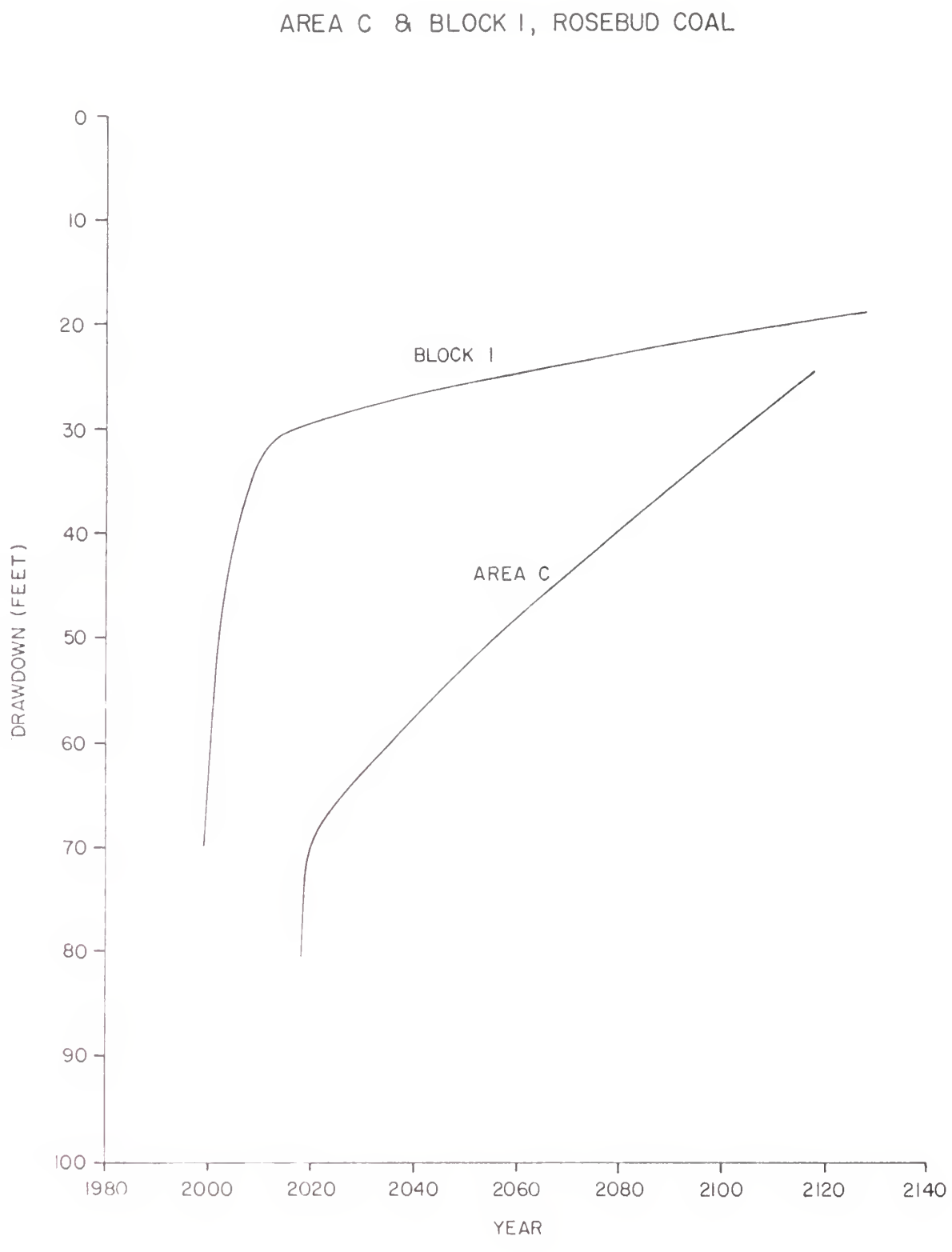


FIGURE 3.2-6 TIME - DRAWDOWN PLOT, AREA C and BLOCK I

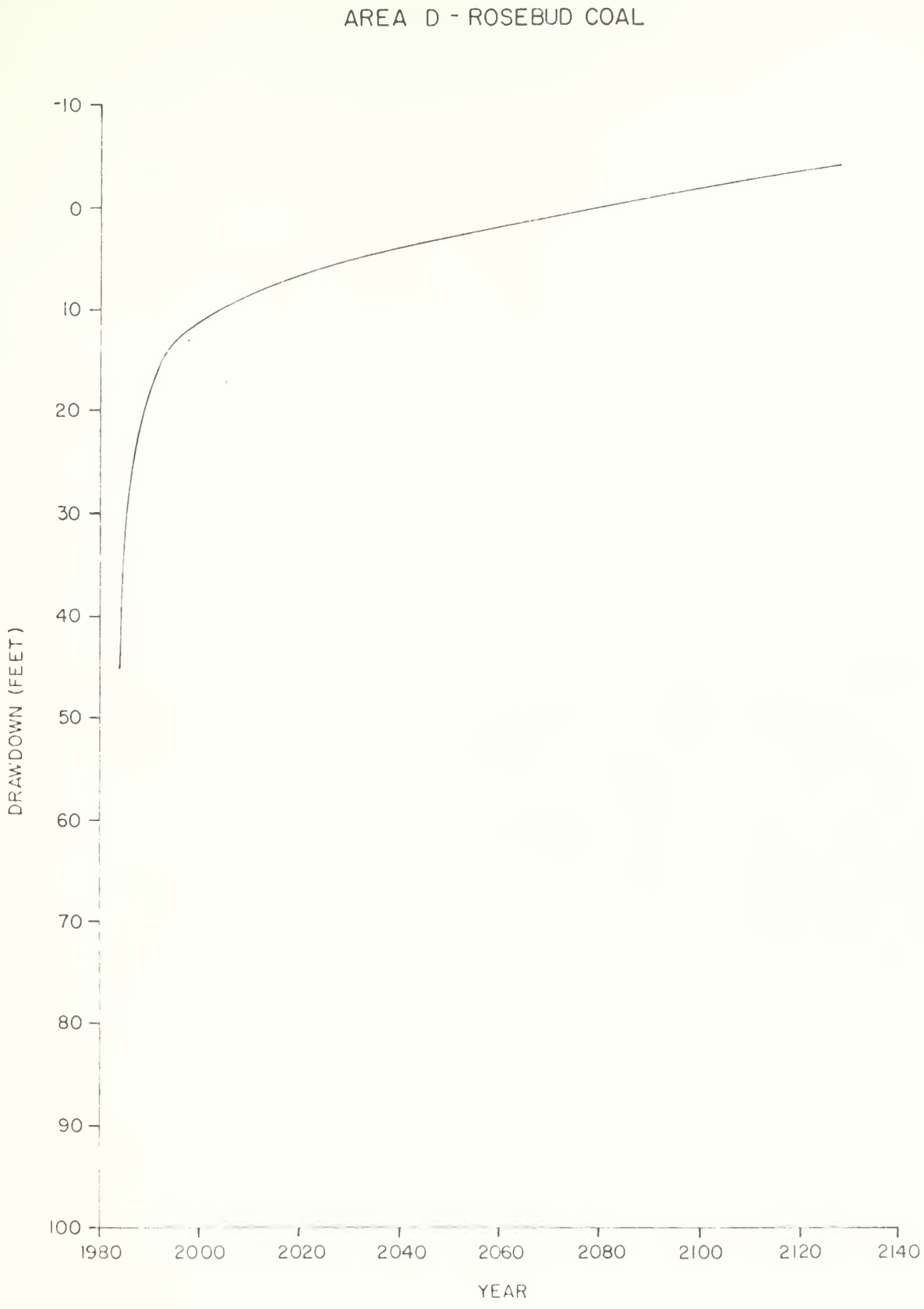


FIGURE 3.2-7 TIME -DRAWDOWN PLOT, AREA D

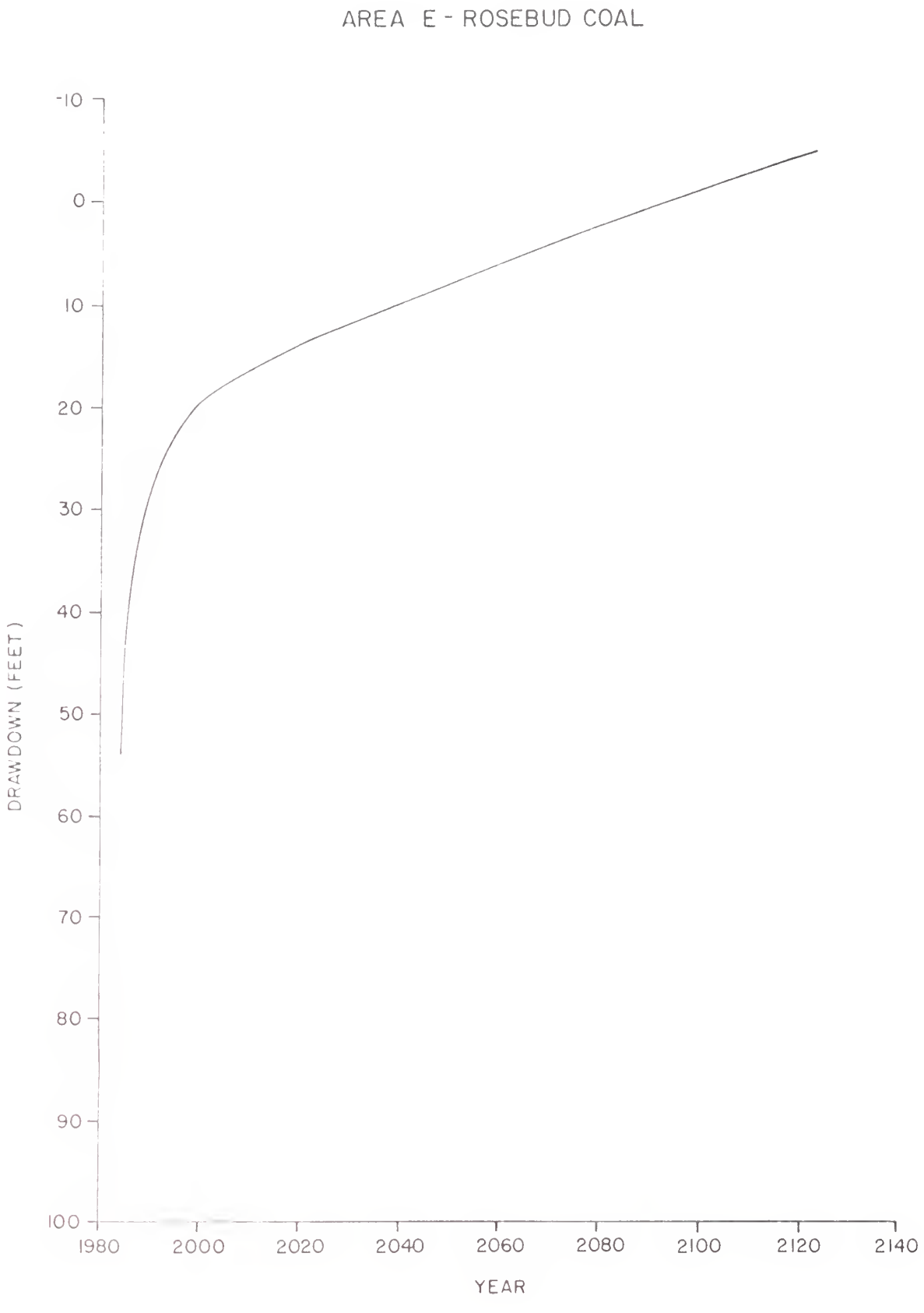


FIGURE 3.2-8 TIME -DRAWDOWN PLOT, AREA E

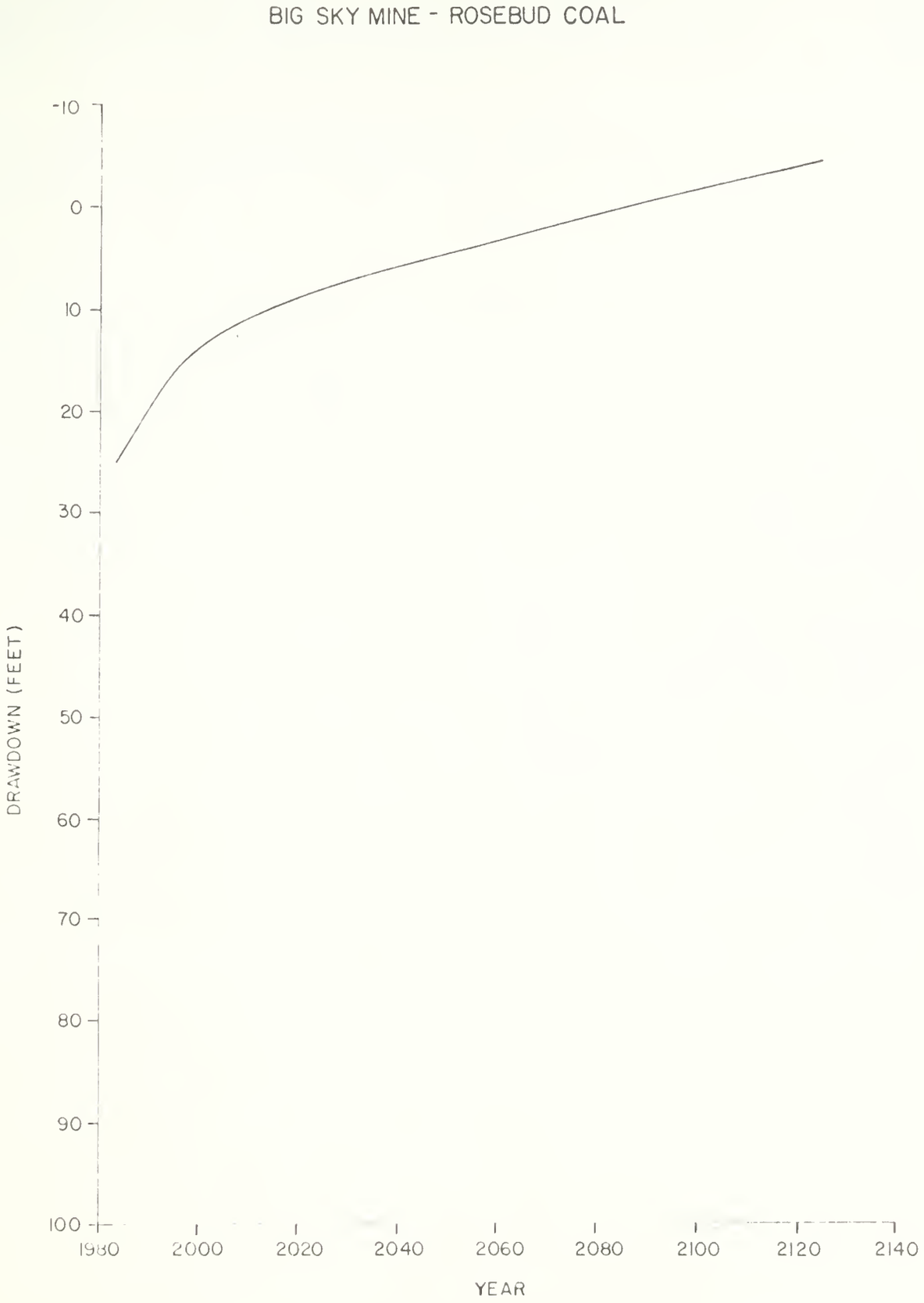


FIGURE 3.2-9 TIME - DRAWDOWN PLOT, BIG SKY MINE

Because of the predicted increase in recharge as a result of the increase in vertical hydraulic conductivity of the spoil material, the potentiometric surface in some cases would be higher than original potentiometric levels. This is illustrated by the negative drawdown values in Figures 3.2-4 and 3.2-9.

No data are available to estimate the seepage from the sediment ponds to the valley fill aquifer system. If seepage does occur, it would attenuate away from the ponds. As the time from the occurrence of the event increases, the seepage moving in the groundwater system would approximate the existing slope of the water table.

A simplified worst case assumption indicates that, if (1) the specific yield of the valley fill along East Fork Armells Creek is 0.2, (2) the total area of the valley fill is approximately 30,000 acres and (3) the valley fill is approximately 10 feet thick throughout the area, there is roughly 60,000 acre-feet of water in the valley fill aquifer. If all runoff from the sediment ponds seeped into the East Fork Armells Creek drainage (which is not likely since some ponds are on other drainages and all of the water will leak), it would represent only a one percent increase in the volume of water in storage in the aquifer. This one percent volume increase will translate into a water level increase that will probably become subject to evapotranspiration.

In summary, the seepage from sediment ponds to the valley fill groundwater system is not expected to affect the quantity or quality of the valley fill aquifers.

Recharge/Discharge Relationships

Local changes in the direction of groundwater flow of the mine area would not significantly change regional flow patterns. Potential impacts to the groundwater recharge/discharge relationship in the long term would depend on (1) the effect that mining and backfilling would have on the recharge to the aquifer and (2) whether there would be a significant change in discharge to surface water.

Table 3.2-3 provides the discharges to the various surface drainages in the area as of 1983 and as of 5, 34, and 135 years later. The 1983 base includes mining impacts that have already occurred in the system. The data indicate that the total discharge to these surface drainages in the mine area would decrease slightly during the life of the mine. The amount of this decrease in discharge is not significant throughout the area. However, individual drainage discharge variations are at times significant; specifically, the 6.8 percent reduction in the combined East Fork Armells Creek and Stocker Creek drainage in 2017. This combined reduction in discharge is 2.4 percent in 2118 and it can be assumed that it would recover to its original amount at some time after 2118. The reduction would serve to lessen the severity of the alleged downstream waterlogging problems now occurring along East Fork Armells Creek.

If mining were to increase the recharge rate of mined areas, the overall effect in 2118 would be to increase groundwater discharge to nearby drainages by about one percent. Mining could also lower groundwater recharge rates by a similar amount if vegetation on reclaimed areas were more vigorous (increased evapotranspiration) than pre-mining vegetation.

In summary, the overall changes in recharge and discharge due to the Rosebud Mine would not be significant.

3.2.1.2.2 Groundwater Quality

The TDS concentration of Rosebud Mine spoils now averages about 2,900 mg/l, but the additive effect of mine spoils passing from one mine area to another could push this average to as high as 4,500 to 5,000 mg/l (personal commun., Van Voast, 1982). Such mine spoil water would be marginally suited for watering cattle and horses, the primary projected post-mining land use. Because higher salt levels would likely increase the water consumption of livestock, more and closer spaced groundwater wells would be needed if spoils water were used. Western Energy Company proposes to use sub-McKay groundwater to replace lost groundwater wells and springs. The sub-McKay water, in most cases, will be an acceptable replacement aquifer even though the average TDS levels of the sub-McKay are slightly higher than that found in pre-mining near-surface aquifers.

Groundwater TDS within the spoils of the Rosebud Mine will remain well above pre-mining levels for thousands of years because water moving through the spoils will pick up salt. Increases in TDS levels in East Fork Armells Creek adjacent to mine Areas A, B, C, and E would likely occur.

Stocker Creek alluvial groundwater quality would change slightly near the headwaters adjacent to Area C, but farther downstream bedrock discharges to the alluvium would not cause any increases. (See Section 3.2.1.1.2.)

There would be some impact from spoils water discharge to headwater tributaries of Stocker Creek. The TDS values for headwater Stocker Creek valley fills groundwater are predicted to increase from a value of 2,500 mg/l to about 5,000 mg/l. Some change in water quality of Stocker Creek might be expected due to increased evapotranspiration. However, TDS concentrations farther downstream in the valley fill of Stocker Creek now range from 1,600 to 1,800 mg/l, indicating that there is dilution by bedrock groundwater inflow. Since this dilution effect would continue, the overall valley fill water quality would not decrease significantly as a consequence of mining.

Pony and Spring Creek alluvium would experience a very small, undetectable increase in TDS as a result of mining in Area D because most of the groundwater flows toward Cow Creek. Increased TDS in the alluvium of headwater tributaries of Cow Creek would last for thousands to tens of thousands of years. Decreased vegetative productivity along the creek bottoms near the mine may occur, but the overall land use pattern of the Colstrip region would not be affected. Increased salt discharges could also decrease aquatic diversity in Cow Creek.

Neither the Rosebud Mine nor the Big Sky Mine would significantly change alluvial groundwater quality of Hay Coulee or of Rosebud Creek. Hay Coulee has very little strippable areas upgradient, and the Rosebud Creek alluvial system is too large and of too poor a quality to be appreciably affected.

3.2.1.2.3 Water Use

Comparison of Figures 3.2-1, 3.2-2 and 3.2-3 shows that the area affected by drawdown in the Rosebud coal aquifer will expand for a long time. Table 3.2-5 lists all the wells and springs that will be impacted for the life of mine. Montana regulations require a company to replace any adversely affected well or spring.

It is expected that along East Fork Armells Creek, Cow Creek, and Stocker Creek a slight decrease in groundwater levels in the valley fill material adjacent to mine areas will cause marginally subirrigated vegetation to be lost for decades. Shallow groundwater will still be suitable for stock watering, although water quality in some places will be poorer.

3.2.2 Surface Water

This section addresses the flow and quality impacts on the surface water system from coal mining in the Rosebud Mine area. This includes the East Fork Armells Creek drainage and several tributaries to Rosebud Creek.

Modeling techniques were used to predict flow impacts to the surface water system.

3.2.2.1 Impacts through 1987

3.2.2.1.1 Drainage Basin Characteristics

The changing location of the active mine pits will continually change the drainage patterns and areas contributing flows. As mining moves through an area, the original flow network will be destroyed, and a similar but new network will be established during reclamation.

3.2.2.1.2 Stream Channel Characteristics

Stream channels within the mine area are being continuously destroyed and reconstructed during mining and reclamation. During the 5-year period, the new channels will probably remain as reconstructed, except if a rare, large flood event should occur. Downstream from sediment ponds some erosion might occur because of the retention of upstream sediment in the ponds.

3.2.2.1.3 Basin Sediment Yields and Geomorphic Stability

During the life of the mine, the company will construct sediment ponds to control sediment and peak flow runoff from disturbed areas. A preliminary listing of proposed ponds (Hydrometrics, written communication, 1982) is presented in the Technical Support Document. A compilation of information for the proposed sediment ponds by mine area follows.

Mine area	Runoff Volume ac.-ft.	Sediment Volume ac.-ft.	Total ac.-ft.
A	180	88.8	268.8
B	89.1	58.9	148
C	685.6	117.1	802.6
D	145	103.1	248.1

During storms, increased sediment yields will occur from regraded but, as yet, unvegetated areas. Downstream sediment yield would not increase, however, because the sediment would be trapped in the sediment retention ponds.

According to Western Energy (personal communication, 1982, Pete Norbeck), 50 percent of the structures will be installed and maintained at any given time; therefore, the net storage per mine area is estimated to be approximately 135 acre-feet for Area A, 74 acre-feet for Area B, 400 acre-feet for Area C and 124 acre-feet for Area D.

3.2.2.1.4 Flow Rate Analysis

Sediment ponds would have the effect of lowering and delaying peak surface flows along the drainages that they are on. The impact of this activity could be considered beneficial, since this in effect lessens the effect of flood events.

The average flow from the mine areas would be slightly reduced by evaporation from the sediment ponds. If the average impoundment size is approximately 10 acre-feet, with a depth of 15 feet, the impoundment surface area will be approximately 0.67 acre (personal communication, 1982, Pete Norbeck). If the water is retained in the structure for a period not to exceed 15 days, the potential evaporation rate would be approximately 0.16 acre-foot. Based on these assumptions the net evaporative consumptive use from East Fork Armells, Stocker, Pony, and Cow Creek would be 65, 20, 1, and 1 acre-feet per 10-year, 24-hour storm. The net impact to the hydrologic regime during periods of flow is a potential maximum surface

flow reduction of less than 4 percent for East Fork Armells, 2 percent for Stocker, 0.2 percent for Pony, and 0.01 percent for Cow Creek.

This reduction in flow would, in some instances, be compensated by the addition of pit pumpage water from runoff and mine dewatering into the ponds.

3.2.2.1.5 Water Use

Stock watering will not be directly affected by mining during the next 5-year period because grazing will not occur in active mine areas. Stock watering ponds destroyed during mining will be reconstructed during reclamation. Assuming flow-through structures are maintained, water flow and quality are expected to remain adequate for anticipated uses. Most diversions for irrigation take place during periods of high flow, which would be trapped in some drainages by sediment ponds, but, for the most part, the short-term retention would have little influence on availability or suitability for irrigation.

3.2.2.1.6 Water Quality

Surface water quality deterioration could only occur if degraded groundwater discharges to surface water, if surface water leaches salts exposed at the surface, or if other factors (such as the power plant expansion) contaminate surface water via groundwater flow.

There will be no significant water quality deterioration from current mining activities within the next 5 years. However, some slight deterioration of surface waters on the east side of the mine area may have already occurred due to the presence of the old Northern Pacific mine spoils. The only runoff-induced quality changes would be increases in sediment loads from unrevegetated areas. However, the sediment would be trapped in sediment ponds, and offsite sediment loads may actually be reduced below premine levels.

3.2.2.2 Impacts through the Life of the Mine and 100 Years Beyond

3.2.2.2.1 Drainage Basin Characteristics

The reclaimed drainage basins would approximate those of the premining environment. Evidence from existing, reclaimed basins in the Colstrip area suggests that the reclaimed drainage basin characteristics would be strongly influenced by the engineering techniques and equipment used to reclaim the spoils.

After reclamation, it is likely that the channel network would expand, creating a higher density of short stream segments due to headward erosion. Such a development would reflect an adjustment of the channel network to the reclaimed hydrologic system, similar to that observed in the currently reclaimed areas.

3.2.2.2.2 Stream Channel Characteristics

As planned by Western Energy, the development of channel profiles that are concave and without knickpoints will decrease the potential for widespread initial instability in the channel. However, both natural and man-induced processes are likely to result in changes to channel geometry, because the reclaimed ephemeral channels in this area will be as inherently unstable as the pre-mine ephemeral channels. The development of gullies can be expected (see Technical Support Document, Section B.4). If left unmitigated, gully evelopment will be a serious impact, but probably no more so than already exists with pre-mine channels. During the bonding period, rills and gullies would be mitigated by Western Energy, but after bond release, it would become the surface owner's responsibility.

Perhaps the most significant man-induced influence on the postmining channels throughout the study area will be the construction of sediment ponds. Upstream of the ponds, changes in channel geometry may be induced by a new base level imposed on the system. This can result in a repeating pattern of erosive and depositional stretches, similar to the stretches observed in undisturbed channels.

Downstream from the sediment ponds, further changes may occur in response to the reduction of peak flow magnitudes and the removal of sediment by the ponds. There could be two major consequences: channel incision and aggradation.* The result of these changes will be a reduction of the low-flow channel capacity (see Technical Support Document, Section B.4 for details).

If there is frequent intermittent flow in the channel, incision may occur below the sediment pond dam. This impact is considered insignificant, considering the relatively short (10 to 20 years) life of the sediment ponds. However, if the ponds are to become permanent, this impact will become greater, possibly causing a lowering of base level downstream.

The most significant impact of the sediment ponds is likely to occur after reclamation, when the ponds are removed and the undersized, aggraded channels are again subjected to uncontrolled discharges from the basins. The probable effect may be an episode of high erosion and downstream sedimentation accompanying entrenchment of the main channel.

3.2.2.2.3 Basin Sediment Yields

On a large scale, the proposed reclaimed landscape appears to be stable, although increased rates of erosion may be associated with subsidence or differential erosion at a reduced highwall interface (Section 3.1).

The Universal Soil Loss Equation (see Technical Support Document, Section B.4) was applied to the grid model to predict post-mine erosion rates* in all basins and to compare these rates to pre-mining erosion. Results indicate that in general the post-mine erosion rates would be similar to, or slightly less than, pre-mining conditions. This is mainly

due to the elimination of short, steep slopes and an increase in vegetative cover, assuming reclamation is successful (Section 3.6).

Figure 3.2-10 is an erosional rate mesh map for various locations in the Rosebud Mine area. The height of the surface above the datum represents the sedimentation measured in tons/acre. The vertical scale was exaggerated for clarity. By comparing grids, relative erosion rates can be discerned. The illustration suggests that the post-mine erosion rates for the disturbed areas will be less than pre-mine erosion rates.

Figure 3.2-11 illustrates those areas where post-mine erosion rates exceed those of the pre-mining environment. The erosion rates were calculated for 400 x 400 grids and exaggerated by 1,000 to visually identify areas that may be sensitive to surface water runoff. The areas identified that have accelerated erosion rates are located parallel to the maximum coal recovery limits in mine Areas A, B, and C. The increased erosion rates in isolated areas is attributed to increased channel slope gradients. Western Energy proposes to use appropriate mitigation techniques, such as revegetation, riprap, plunge pools, drop structures, and/or bluff extensions to control erosion in these areas. In all cases, overall basin sediment yields from reclaimed disturbed areas will be less than the pre-mine environment. This is attributable to Western Energy's post-mine topographic design and revegetation plans. The final reclaimed mine area will be topographically subdued when compared to pre-mine topographic characteristics. This will reduce the potential for erosion and offsite sedimentation.

Area-wide settling is common in most post-mining landscapes and occurs during the first 10 years after recontouring. With time, replaced materials would settle and approach a density similar to that which existed prior to mining. Groenweld and Rehm (1980) indicate that there would be less settlement and it would occur more rapidly with sandy material as compared to silty material. Settlement is likely to be less significant at Colstrip than in many other sites, because of the sandy character of the spoils.

Piping associated with subsidence may be a localized problem for several years after initial regrading and revegetation. At or near the surface, piping begins as a crack either in the surface of the exposed spoils or at the topsoil/spoil interface, allowing surface runoff to flow into the sub-surface of the spoils. However, surface cracking will not always result in the development of piping. Piping is most likely to occur when an avenue for potential water movement is present in the subsurface of the spoils. Such an avenue of flow can result from fracturing within the spoils due to settling between differentially compacted areas, or within areas of poorly compacted spoils. Such differential settlement is most likely at the highwall interface between coherent overburden and the spoils materials, and between areas of spoils handled by different equipment. If left unmitigated, piping and the consequent gullying it causes would be a serious impact to the stability of the reclaimed landscape. Piping has been a problem at the Rosebud and Big Sky Mines. However, it is a short-term problem, occurring 2 to 5 years after reclamation. It is anticipated that at the time of bond release all piping problems will have been mitigated.

VERTICAL EXAGGERATION = 100 TIMES

——— WATERSHED BOUNDARY
····· PERMIT AREA BOUNDARY (APPROX.)
A,B,C,D,E MINE AREA DESIGNATIONS
HEIGHT ABOVE SURFACE REPRESENTS EROSION RATES

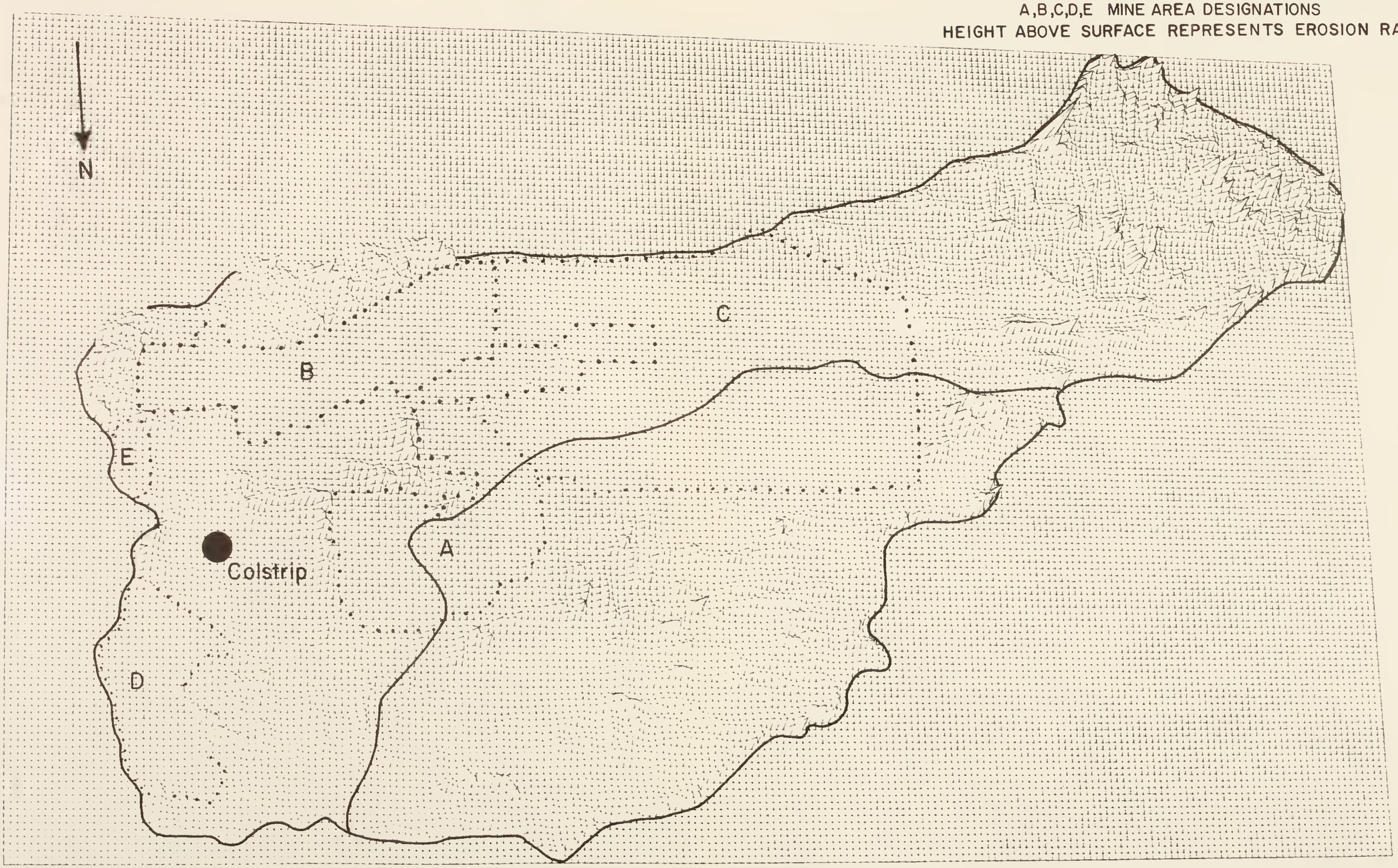


FIGURE 3.2-10 COMPUTER-GENERATED POST-MINE EROSIONAL RATES, ROSEBUD MINE

VERTICAL EXAGGERATION = 1,000 TIMES

——— WATERSHED BOUNDARY
····· PERMIT AREA BOUNDARY (APPROX.)
A,B,C,D,E MINE AREA DESIGNATIONS
HEIGHT ABOVE SURFACE REPRESENTS EROSION RATES

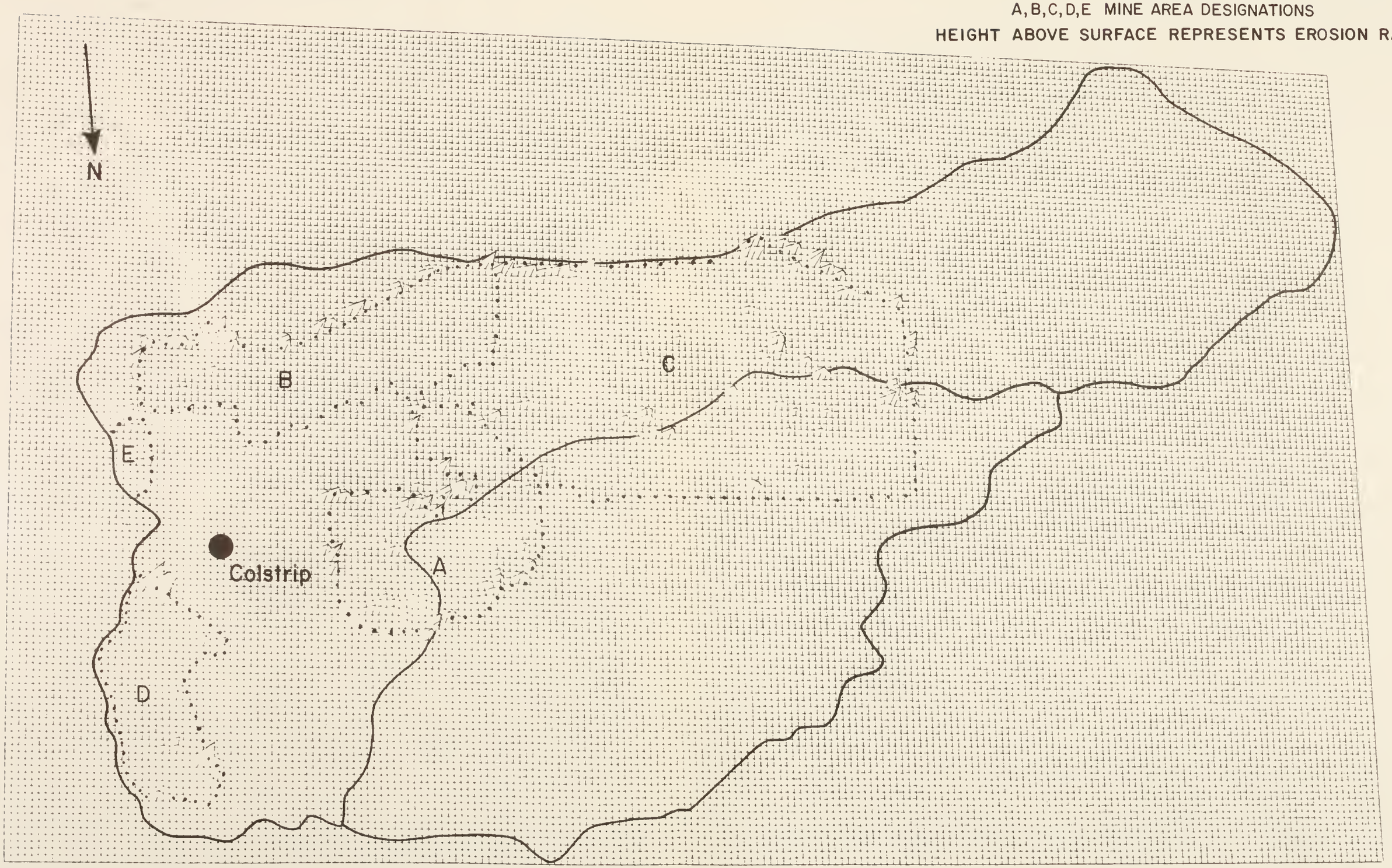


FIGURE 3.2-11 COMPUTER-GENERATED POST-MINE EROSIONAL RATES, ROSEBUD MINE, WHERE POST-MINE EROSION EXCEEDS PRE-MINE EROSION

3.2.2.2.4 Flow Rate Analysis

A surface-flow model was used to compare pre- and post-mine surface flows. Surface flows occurring during mining were not evaluated quantitatively due to the changing nature of the drainages as reclamation progresses. One of the impacts on surface flows during mining is attenuation of peak flows due to the impoundment of snowmelt and storm runoff in the sediment ponds. This impact would also cause base flow to be prolonged slightly, due to the gradual release of flow from the ponds after treatment. The major impact to surface flows during mining, however, would be a decrease in total volume of flow from the mined areas due to increased evaporation and seepage from the sediment ponds and the use of sediment pond water for dust suppression.

Post-mine flow volumes and peak flows would be slightly reduced, assuming that reclamation is successful, due to a slight increase in vegetation densities and infiltration rates. Tables 3.2-6 and 3.2-7 illustrate this difference between pre- and post-mining surface flows for the East Fork Armells Creek basin.

Only a small portion of the Rosebud Mine affects tributaries to Rosebud Creek. The estimated total reduction in average annual flow of Rosebud Creek during mining (assuming all sediment ponds in place at the same time) is about 320 acre-feet per year, or about 1 percent of the mean annual flow at the gaging station near Colstrip. Upon cessation of mining and removal of most sediment ponds, discharge of surface waters to the Rosebud Creek drainage would revert to pre-mine conditions.

Sediment ponds will have only a minor effect on the post-mine surface flow regime since most or all ponds would be removed when the reclamation bond is released.

3.2.2.2.5 Water Use

Surface water use along East Fork Armells Creek in the Colstrip area should not be significantly affected as a result of quality and quantity changes from mining, except possibly during low flows.

Slightly less water would be available for stock ponds during mining as a result of sediment impoundments and the resulting loss from seepage and evaporation; however, the water quality in the ponds should be the same as present water quality and would be suitable for present uses. Downstream water levels might decrease slightly with the decreased groundwater discharge to the drainage. During the years 2003-2017, portions of East Fork Armells Creek are proposed to be mined through. Western Energy will likely utilize a pumping scheme to move water from the upstream side of the pits to a location downstream from the pit. Since the water will not be consumptively used, downstream water users will not be affected.

As discussed in Section 3.2.2.1.6, the quality of the surface flow in the Rosebud Creek tributaries may decrease slightly because of inflow of spoils groundwater into the system.

TABLE 3.2-6
PRE- AND POST-MINE PEAK FLOWS
(in cubic feet per second)

	Recurrence Interval (Years)											
	2		5		10		25		50		100	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
East Fork Armells Creek at Stocker Creek (47.72 sq.mi.)	326	230	708	557	1,070	880	1,670	1,430	2,100	1,840	2,550	2,260
Stocker Creek (26.11 sq. mi.)	218	163	457	302	676	583	1,030	919	1,280	1,160	1,540	1,400
East Fork Armells Creek below Stocker Creek (73.83 sq. mi.)	541	391	1,160	935	1,740	1,460	2,700	2,350	3,380	2,990	4,090	3,670

TABLE 3.2-7
PRE- AND POST-MINE SURFACE FLOW VOLUMES
(in acre feet)

	Recurrence Interval (Years)											
	2		5		10		25		50		100	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
East Fork Armells Creek at Stocker Creek (47.72 sq. mi.)	292	190	725	536	1,170	912	1,960	1,600	2,550	2,130	3,183	2,700
Stocker Creek (26.11 sq. mi.)	196	147	464	375	733	612	1,210	1,040	1,560	1,360	1,930	1,710
East Fork Armells Creek below Stocker Creek (73.83 sq. mi.)	488	337	1,190	911	1,900	1,520	3,170	2,640	4,110	3,490	5,110	4,410

See Technical Support Document for detail

Flood irrigation downstream from Colstrip would at most, be slightly and only temporarily affected by mining activities in the study area. Stream flow is used for irrigation only during periods of high flow, when adequate quantities are available and the quality is good. This would continue to be the situation after mining and the water quality during high flow should be about the same as present water quality. Water quality during low flow periods is suitable for livestock watering but may become unsuitable after mining because of mine spoil water. During mining, sediment ponds would cause peak flow attenuation that may have short-term affects on flood irrigation. Long-term effects (post-bond release) should be negligible, although a very slight decrease in flow volume and peak flows may occur.

As indicated by Table 3.2-3, groundwater discharges to surface water will not change significantly from the present.

During low-flow conditions, surface flow is predominantly groundwater discharging from the valley fill system. Generally, with time, the groundwater discharge will be of a lower quality and the surface water quality will decrease somewhat. The decrease is not expected to affect the use of the water for stock watering. However, it is possible that surface expressions of salt may develop in subirrigated areas.

Any new springs issuing from the mined area will have TDS concentrations similar to their sources. If the source is spoils, the spring water may have TDS concentration of up to 5,000 mg/l.

Springs in areas where the groundwater system has been impacted by mining will probably experience declines in quality and quantity of flow.

3.2.2.2.6 Water Quality

Surface water quality impacts would occur during low flow periods. There are two possible ways in which surface water quality changes might take place: by changes induced directly from surface runoff/overland flow; and by changes induced due to modifications in quality of groundwater, which then discharges to the valley fill/surface water system.

During the long-term, little if any direct impact on surface water quality is anticipated due to surface runoff. Before mine bond release, any flow which occurs would be routed through sediment retention ponds, where sediment would be trapped. Water released should be cleaner than under natural conditions. Due to the change in grade induced by the presence of the sediment ponds through the life of the mine, all surface water drainages would reestablish grade when the ponds are removed. This process would result in a small amount of channel incision (erosion) and deposition but should not produce noticeable increases in suspended sediment.

Because of revegetation requirements, it is likely that for some period of time after vegetation is reestablished, mined areas would be more densely vegetated than nonmined areas. The effect of the extra vegetative cover would be to decrease sheet and rill erosion and decrease the peak

flood flows by detaining some runoff and increasing infiltration. Storm runoff, for this reason, may have less suspended sediment than during pre-mining floodflow conditions.

Greater potential exists for long-term effects on surface water quality via groundwater. Normally, no flow exists in East Fork Armells Creek above Colstrip or any of the tributaries to Rosebud Creek except during runoff periods. All groundwater which discharges from bedrock to East Fork Armells and tributaries to Rosebud Creek becomes part of the valley fill system and thus makes up the baseflow portion of flow. Therefore, there is a potential for spoils water from various mined areas to affect valley fill water quality. Near Colstrip the valley fill water discharges to the stream. Therefore, along East Fork Armells Creek there is the potential for spoils water to affect surface water. At present, seepage of industrial waters and discharges from Colstrip's sewage treatment facility offset potential TDS increases downstream of the Rosebud Mine. Should these sources stop, TDS levels may increase slightly, although downstream uses would not be affected. (See Section 3.2.3.)

Assuming post-mining groundwater levels are reestablished in approximate conformance with existing levels, groundwater flowlines would be similar to those under pre-mining conditions (Figure 2.2-8). Examination of this figure indicates that under existing conditions a small section of Area B plus the Big Sky Mine, contribute to flow in Lee, Miller, and Hay Coulees, while Cow Creek receives contributions from Areas D and E. Spring and Pony Creeks will receive a minimal amount of flow from Area D.

Mining above the Cow Creek drainage could slightly change surface water quality near the headwater adjacent to the mine, but further downstream changes would be minimal. (See Section 3.2.1.2.2.) Bedrock discharges to the Cow Creek alluvium and surface water runoff are both of better quality and would overwhelm the small amount of spoils water (5 gpm) added to the system. Because of the small areas affected by the Rosebud Mines in the headwaters of Lee, Miller, and Hay Coulees, the water quality impacts will be insignificant.

3.2.3 Cumulative Hydrologic Impacts

This section addresses the hydrologic impacts of all mine-related development in the Rosebud Mine area, including the Rosebud and Big Sky coal mines, and addresses the cumulative effects of mining with other area projects impacting hydrology such as the Montana Power Company's Colstrip generating station, the town of Colstrip, and the old mining activities of Northern Pacific. Section 3.2.4 discusses mitigation measures for cumulative impacts.

3.2.3.1 Groundwater

This section addresses the impacts that all mining and mine-related development would have on the quality and quantity of groundwater, either originating in or flowing through the hydrologic study area.

3.2.3.1.1 Impacts through 1987

3.2.3.1.1.1 Groundwater Flow

Current and proposed mining will change the physical properties of the near-surface aquifers. The Rosebud coal and overburden would be removed and replaced by spoils. A rubble zone at the base of the spoils, formed from rock fragments and waste coal, would have aquifer properties similar to the unmined coal and overburden.

The old Northern Pacific spoils on the east side of the mine were unreclaimed until relatively recently. The spoils piles and enclosed basins retained precipitation and functioned as recharge areas. Increased recharge in the older, unregraded spoils has likely increased groundwater flow into the headwaters of Cow Creek. The amount of this additional flow cannot be quantified. With the reopening of the Rosebud Mine in 1968, and subsequent mining of Pit 6, much of the older spoils were regraded and revegetated. This measure reduced the amount of surface recharge to the spoils. Hydrologic conditions within the spoils are now similar to conditions in spoils created by current mining.

Mining has lowered water levels of the shallow aquifers near active mine areas, thereby influencing groundwater flow. Table 3.2-2 and Figure 3.2-1 show the predicted drawdown for year 1987.

Industrial and municipal development from the power plants and town of Colstrip have artificially induced recharge into the near-surface aquifers. Table 2.2-2 summarizes the seepage losses from the various ponds associated with the power plant complex and the outflow from the sewage treatment plant. These sources add approximately 288 gpm (464 acre-feet per year) to the groundwater flow system near Colstrip. Approximately 13 gpm (22 acre-feet per year) of this will eventually contribute to the Cow Creek system. The remaining 275 gpm (422 acre-feet per year) will flow into the East Fork Armells Creek system. A new fly ash pond being constructed in the headwaters of Cow Creek could have a maximum seepage rate of 104 gpm (166 acre-feet per year), although the actual seepage rate will be considerably less. Seepage control measures include a clay liner, interceptor wells downgradient from the pond, a perimeter slurry trench, and an underdrain system. As such, seepage from the pond will be less than the maximum seepage rate.

Three new industrial ponds associated with Power Units 3 and 4 are being constructed due east of the existing ponds near the plants. (See Figure 3.2-13.) Combined, they will lose an estimated 20 to 25 gpm (32 to 40 acre-feet per year), most of which will flow toward Cow Creek. (Existing ponds have created a groundwater mound under them, which will limit westward movement of new pond seepage).

Except for alleged waterlogging problems downstream from Colstrip in East Fork Armells Creek, the cumulative impact of all activities on the regional groundwater flow system near Colstrip is insignificant.

Figure 3.2-13 Reference Map of Rosebud Mine Spoils, Industrial and Municipal Wastewater Ponds, and Associated Monitoring Wells

Key to Power Plant Complex:
- A — 1 & 2 Fly Ash Pond
- B — 1 & 2 Fly Ash Pond
- C — 1 & 2 Cooling Tower Blowdown Pond
- D — 1 & 2 Fly Ash Clearwater Pond
- E — 1 & 2 Wash Tray Pond
- F — 1 & 2 Bottom Ash Clearwater Pond
- G — 1 & 2 Bottom Ash Storage Area
- H — 1 & 2 Brine Waste Ponds
- I — 3 & 4 Wash Tray Pond
- J — 3 & 4 Scrubber Drain Pond
- K — 3 & 4 Bottom Ash Pond
- L — 9 acres reserved for 3 & 4 Brine Waste Ponds
- M — Sediment Retention Pond

Key to Wells:
Contributing Unit
- A — Alluvium
- R — Rosebud
- I — Interburden
- C — Composite
- S — Shallow (McKey Overburden)
- M — McKey Coal Seam
- D — Deep

N

ONE MILE

AREA D

AREA E

FLY ASH EVAPORATION POND (1 & 2)

FRESHWATER SURGE POND (1, 2, 3, 4, & COMMUNITY)

SEWAGE TREATMENT PLANT

FLY ASH EVAPORATION POND (3 & 4)

GW-11 GW-15 GW-14

PZ-17 PZ-21 PZ-20 PZ-22

EAP514 EAP522 EAP528 EAP515 EAP529 EAP527

Colstrip

Golf Course

NORTHERN

3.2.3.1.1.2 Groundwater Quality

Mining, industrial, and municipal development near Colstrip will change groundwater and, in some places, surface water quality. Both mining and industrial development would tend to increase the salinity of receiving waters. Individual elements comprising the dissolved constituents in water would remain below levels that could adversely affect the natural or human environment and will therefore not be discussed.

The method used to calculate changes in surface- and groundwater quality at Colstrip is similar to the method used (Van Voast and Thompson, 1982) for assessing the effects of 10 mines along the Tongue River drainage. First, the total amount of salt contained in the receiving water was determined. Then, the amount of flow and dissolved constituents contributed by various levels of mining and industrial development were calculated. The primary objective was to derive reasonable estimates of changes in ground- and surface-water quality of nearby streams (including both alluvial groundwater and surface water), inasmuch as streams in the area are the collectors of most shallow groundwater.

The complexities of geochemical reactions as water passes through geologic material to the receiving stream system were largely ignored. Experimental evidence indicates that spoils water may improve slightly as it travels through the coal, but by how much and by what means have yet to be determined (Bob Davis, U.S. Geological Survey, Helena District, oral commun., February 1983). The followng estimates, therefore, may tend to be slightly worse than would actually happen.

The following assessments are only estimations. Because of the geologic and hydrologic variability of the bedrock and unconsolidated deposits, exact numbers cannot be determined. Rather, a range of values is presented, with a single value selected in some cases which represents the "most probable case." The rationale for selection of various numbers and the underlying calculations are outlined in an addendum to the Technical Support Document.

The overall groundwater quality of the Colstrip area has already been affected by past mining activities and by industrial and community development. Pre-mining groundwater quality conditions for the study area were estimated in two ways: (1) by subtracting estimated impacts from old mining and developments from present conditions, and (2) by utilizing predevelopment water-quality data where available.

Valley Fill

The older Area A mining and part of the municipal/industrial development at Colstrip are already affecting the quality of groundwater in East Fork Armells Creek. The pre-mining water quality for the East Fork Armells Creek alluvium ranged from 1,300 to 3,000 mg/l, with a mean of about 2,500 mg/l. Current and proposed mining in Areas A and B will continue to increase the TDS by about 800 to 1,500 mg/l (mean of about 1,000 mg/l). The industrial and municipal development will also continue to add salts,

increasing TDS of alluvial groundwater downstream from Colstirp by another 500 to 2,000 mg/l (mean of about 1,500 mg/l).

Combined mining and nonmining sources will increase valley fill groundwater TDS values from a mean of 2,500 mg/l TDS to over 5,000 mg/l. The industrial and municipal development appears to have a mixed effect on East Fork Armells Creek. In the immediate vicinity of the generating station, the industrial ponds increase the TDS levels to greater than 5,000 mg/l. Downstream, the surge pond leakage dilutes this to about 3,500 to 4,700 mg/l. Still farther downstream, the fly ash pond leakage reverses this trend, increasing the TDs to between 4,500 to 5,200 mg/l. Even though the predicted increase is large, the impact on stockwatering would be minimal; the water would still be acceptable for stockwatering (its only anticipated use). TDS increase may cause some decreased vegetative productivity (Bernstein and Mass, 1975; Hoffman, 1977) in the subirrigated portion of the creek bottoms. (See Sections 3.2.3.1.1.3 and 3.2.3.1.2.3.)

The Old Northern Pacific and Pit 6 spoils have probably affected the quality of groundwater in the headwaters of Cow Creek and South Fork Cow Creek. The pre-mining water quality in the shallow aquifers was estimated to range from 2,500 to 4,000 mg/l TDS, with a mean of about 3,500 mg/l TDS. The tributary to Cow Creek with the highest TDS levels averages 4,700 mg/l. Several ponds located on mine spoils above this tributary have TDS levels of approximately 4,000 mg/l and probably contribute to the high TDS concentration in the alluvium downstream.

The Old Northern Pacific spoils will probably maintain TDS levels that are about 200 to 1,000 mg/l higher than pre-mining levels for thousands of years. The resulting overall TDS range in the Cow Creek alluvium will be about 2,700 to 5,000 mg/l adjacent to the mine. Increased alluvial groundwater flow (120 to 200 gpm) farther downstream at the sprader dikes in section 32 is attributed to recharge from the sub-McKay aquifer. Discharge from the spoils (2 to 5 gpm) will continue to be diluted to about 2,500 to 3,000 mg/l TDS by the sub-McKay recharge.

The groundwater quality impacts of the industrial and municipal developments near Colstrip will not reach the Cow Creek headwaters within the next 5 years because of the low hydraulic conductivity of the materials involved and because of the interception of pond seepage by active mine pits.

Mining in Pit 6 and Area E plus mining at Peabody's Big Sky Mine will continue to affect the alluvial water quality of Hay, Coal Bank (Emilee), Miller, and Lee Coulees. An estimated 600-mg/l increase in the alluvial water of Hay Coulee is attributed to mining activities in Area E and Pit 6. An estimate of Big Sky Mine influences on Miller and Coal Bank Coulee alluvial water indicates that TDS levels may have inceased from 500 to 2,000 mg/l (mean 1,300 mg/l). Lee Coulee will not have any effect on the other tributaries to Rosebud Creek.

The cumulative impact of all mining activities through 1987 on the Rosebud Creek drainage will be less than a 1 percent increase in TDS in the vicinity of the Rosebud and Big Sky Mines. Municipal and industrial activities will not affect the Rosebud drainage in this time period.

Deeper Aquifers

Current and proposed mining through 1987 will have no appreciable impact on the deeper aquifers. There has been an observed increase in TDS in groundwater in the McKay overburden and McKay coal in the immediate vicintiy of the power plant. TDS levels in the McKay overburden observation wells have increased from around 2,000 to 3,000 mg/l to as much as 16,000 mg/l. Most wells sampled ranged from 7,000 to 8,000 mg/l TDS. About one-third of an estimated 36 gpm of this poor-quality seepage is toward Cow Creek, but it would not reach the Cow Creek drainage within 100 years. The other two-thirds of the seepage is moving toward East Fork Armells Creek. Evidence that the degraded McKay overburden and McKay groundwater is moving toward East Fork Armells Creek alluvium is the increase in TDS of alluvial well 1-S, located between the industrial ponds and the creek. TDS of the well water has steadily increased from a pre-mining level of less than 3,000 mg/l to a current level of about 8,700 mg/l. (See Valley Fill for a discussion of pond seepage influences on East Fork Armells Creek.)

The existing fly ash pond, northwest of Colstrip, has increased TDS levels in the sub-McKay aquifer for a distance of 800 feet downgradient. In several observation wells, TDS has inceased from a range of 2,000 to 3,000 mg/l to a range of 4,400 to 10,00 mg/l. The direction of groundwater flow in the sub-Mckay around the pond appears to be toward the small ephemeral creek in which the pond is situated. Sub-McKay groundwater appears to follow the slope of the topography draining toward topographic lows. Pond seepage through both the sub-McKay and tributary alluvium appears to be affecting the East Fork Armells Creek alluvium downstream. Monitoring wells WA-153 and WA-154, about one-half mile downstream from the mouth of the tributary below the fly ash pond, have slightly higher TDS levels than those recorded in wells P-11 and P-12 upstream from the tributary.

3.2.3.1.1.3 Groundwater Use

The impact of current and proposed mining will be the destruction of 7 wells and 3 springs, and the lowering of the water levels for an additional 12 wells and 4 springs. The impact of the old mining and industrial and municipal development will be a reduction in water quality in nearby shallow groundwater.

Table 3.2-5 summarizes the impact of the current and proposed mining on groundwater levels for all the wells and springs that will be impacted in the Rosebud Mine area. Approxiamtely 30 to 40 additional wells are within the area of potential water-quality deterioration. An unknown but small number of these may be affected by spoils water seepage, since most of these are completed in deeper aquifers.

Montana regulations require mining companies to replace any water supplies affected by mining. Sufficient supplies are available from deeper aquifers to replace supplies affected by mining, as well as by nonmining activities. Increased pumping costs due to the greater depths of wells would be fairly small. (See Section 3.2.1.1.3 for cost analysis.)

Combined mining and industrial activity would raise TDS levels in the alluvium of East Fork Armells Creek to 4,000 to 5,000 mg/l. Similar increases in TDS levels in the headwaters of Cow Creek are possible. This alluvial groundwater would be suitable for livestock watering, the primary use of groundwater. Alluvial groundwater quality is already above acceptable levels for irrigation and domestic water supplies. Vegetation along the subirrigated portions of East Fork Armells Creek may shift to more salt-tolerant species as a result of alluvial and surface water quality changes.

3.2.3.1.2 Impact Through Life of Mine and 100 Years Beyond

3.2.3.1.2.1 Groundwater Flow

The impacts to groundwater flow for the life of the mine would be similar to those for the 5-year period. As with the 5-year period, the major effect of current and proposed mining is drawdown in the shallow aquifers, reducing the groundwater flow. Table 3.2-2 and Figures 3.2-2 and 3.2-3 show the predicted drawdown for the years 2017 and 2118. Figure 3.2-3 shows that the zone affected by drawdown will increase by about 2 miles by the year 2118.

Seepage losses from the power plant complex ponds and the sewage treatment plant will continue at about the same rate as for the 5-year period for EFAC. However, the residual effect will be seen for a number of years as the added water is absorbed into the regional groundwater flow system.

Three new ponds are being constructed on the old Northern Pacific mine spoils which will seep an estimated 25 gpm. These pond seepages will raise groundwater levels in the spoils, and some of this seepage water will eventually reach the Cow Creek headwaters. The flow in the Cow Creek alluvium farther downstream is more than 120 gpm, so the addition of the pond water seepage would be less than 20 percent of existing flows. The alluvial groundwater table would be raised at most 3 to 4 feet, but even this amount could influence vegetative productivity locally, where the water table is shallow.

Seepage from the proposed fly ash pond in Cow Creek could add slightly to the potential groundwater elevation increase in Cow Creek.

Seepage from all the industrial ponds will cease once the power plant ceases operation and the ponds are reclaimed. However, the residual effects will remain for a much longer time.

The long-term cumulative impact on groundwater flow will continue to be insignificant in the Rosebud Mine area. The increased ground- and surface-water flow along East Fork Armells Creek that may be contributing to the alleged waterlogging problems below Colstrip will continue for some time after the ponds are reclaimed. After all reclamation, the increased groundwater will slowly dissipate, and any contribution to waterlogging will slowly disappear.

3.2.3.1.2.2 Groundwater Quality

The impacts to groundwater quality discussed in the impacts through 1987 section would continue for the life of the mine and the generating station. After mining and reclamation are completed, the generating station abandoned, and the area reclaimed, the additional loading will cease, but the poorer water already in the system will continue to affect groundwater quality for many thousands of years.

The long-term impacts from current and proposed mining are described in Section 3.2.1.2.2. It is estimated that the TDS in the spoils will reach a maximum level of about 5,000 mg/l.

The mining impacts to the valley fill aquifer tend to be cumulative as mining progresses. Thus, the TDS levels of the valley fill will slowly increase downstream through the life of the mine. By the end of the mining, TDS levels from mining and nonmining sources may range from 4,000 to 5,500 mg/l along the length of East Fork Armells Creek adjacent to mined areas and downstream. TDS levels will remain this high for 5,000 to 10,000 years.

Until the generating station is abandoned and the area reclaimed, the increase in TDS levels in the East Fork Armells Creek alluvial water will continue to be maintained by seepage from industrial pond water (ponds adjacent to Colstrip for Power Units 1 and 2 and the 1 and 2 fly ash evaporation pond). After the generating facilities are no longer used, the seepage from these industrial ponds will stop. However, the mound of degraded groundwater beneath the ponds will remain for decades and continue to add to the salt loading of the East Fork Armells Creek alluvium. As the groundwater mound dissipates, this salt loading will diminish.

As long as sewage treatment plant discharge and surge pond seepage continue, TDS increases caused by mining and industrial wastewater seepage will be limited by inflow from these two water sources. The amount of cumulative TDS-level increase in the valley fill of East Fork Armells Creek below Colstrip due to all mining and nonmining development is difficult to assess. The combined discharges of all nonmining facilities exceeds the capacity of the valley fill groundwater system. Most of the industrial input water is moving downstream as surface water, adding about 0.5 cfs (225 gpm) to flow of the creek. Because of the close relationship between surface- and groundwater in Armells Creek below Colstrip, impact on both are discussed in the following paragraphs.

During average flow conditions, TDS concentrations of surface water of East Fork Armells Creek is about 3,500 mg/l at the USGS gaging section 7 miles downstream. The TDS concentration of the alluvial groundwater in wells WA 153 and WA 154 is 4,500 mg/l downstream from all development. The weighted average TDS concentration in the surface- and groundwater system would be around 3,600 mg/l. Continued mining and municipal and industrial activity would raise the weighted average to about 4,100 to 5,000 mg/l.

Assuming low-flow conditions, the average TDS concentration of the surface and the alluvial water is presently about 4,500 mg/l (probably

higher than predevelopment levels). Mining and development would further increase TDS concentrations to about 5,300 to 6,500 mg/l. In either case (mean or low flow), the estimated TDS increase would be about 1,000 to 1,400 mg/l for the combined surface- and groundwater system. This TDS increase would probably occur mostly in the alluvial groundwater, rather than in the surface waters.

Spoils waters from mine Areas E, D, Pit 6, and possibly portions of Area B will dischared to the Cow Creek drainage. Spoils waters from mine Area A, most of Areas B and C, and a small part of Area D will discharge to East Fork Armells Creek. TDS concentrations in Rosebud mine spoils from these mine areas will probably not exceed 5,000 mg/l, and most of the spoils water will remain in the 2,000 to 4,000 mg/l TDS concentration range.

Spoils waters discharging from Northern Pacific and Pit 6 spoils will maintain alluvial water quality in the headwaters of Cow Creek at 500 to 1,000 mg/l levels above estimated pre-mine conditions. Following mining and reclamation of Area E, discharge of spoils waters could possibly increase, resulting in a small increase in headwater alluvial water TDS. Following reclamation of Area D, two additional ephemeral tributaries to Area D could be similarly affected. Inflows of substantial quantities of sub-McKay water water within 3 miles of the mine appreciably dilute TDS levels in the Areas E and D mine spoil discharges. Total TDS levels in the Cow Creek alluvium would be increased by less than 5 percent, from 2,700 mg/l to 2,800 mg/l.

Continued mining of the East Fork Armells Creek drainage area upstream from Colstrip will increase TDS levels of the alluvial water to above pre-mining levels. Pre-mining TDS levels are generally less than 2,500 mg/l upstream from Colstrip but would increase due to mining to levels of 4,000 to 6,000 mg/l. Eventually, most of the East Fork Armells Creek alluvial water adjacent to the mined areas would have TDS concentrations this high as a result of mining. (See Water Use.)

In addition to mining, groundwater below Colstrip will also be impacted by industrial activities. Seepage of poor-quality water from existing and proposed industrial ponds will continue to increase the areal extent of degraded groundwater. If left unmitigated, these ponds would add considerable salt loading to both East Fork Armells Creek and Cow Creek. Industrial pond seepage and Area A mine spoils water has already increased the TDS level of East Fork Armells Creek alluvial water to over 4,000 mg/l. Continued seepage from the industrial ponds in combination with spoils water inflow will elevate concentration above 5,000 mg/l for at least several miles downstream from Colstrip. (See Groundwater Use.)

Much of the industrial pond seepage and municipal discharges to East Fork Armells Creek becomes surface-water flow because the capacity of the alluvium to transmit groundwater is exceeded. Therefore, alluvial groundwater changes will lead to surface water quality changes. (See Section 3.2.3.2.)

Seepage from existing industrial ponds has raised TDS concentrations in the underlying bedrock from about 3,000 mg/l to an average of more than 7,000 mg/l. The three new ponds being constructed for Power Units 3 and 4 will leak an addition 20 to 25 gpm. As a result, the mound of degraded groundwater below the existing ponds will increase. Because the new ponds will receive wastewater that contains much more salts than the existing ponds, the quality of the underlying groundwater will probably be further degraded.

Following reclamation of Area E (within 4 years), most of the seepage from the new ponds will move toward the headwaters to Cow Creek. TDS concentrations of alluvial groundwater of headwater tributaries of Cow Creek could be increased to over 5,000 mg/l. Such changes probably would not occur within 100 years; however, their influence would last for several centuries, until the mound of poor-quality water dissipates. Areas downstream from the headwaters may also experience increased salt loading. In the worst-case situation, TDS levels could double from 2,700 mg/l to more than 5,000 mg/l. The actual increases will probably be somewhat less due to dispersion, adsorbtion, and storage attenuation of the poor-quality water as it moves toward Cow Creek.

The fly ash evaporation pond being constructed in the mid-reaches of Cow Creek and South Fork Cow Creek will add some salts to these two creeks. Maximum seepage rates were estimated to be about 104 gpm, but mitigation measures are expected to reduce maximum seepage below this amount. Not all the evaporating pond seepage can be collected by the proposed mitigation measures, despite the numerous safeguards. However, even fairly small seepage rates would add to the TDS levels of Cow Creek because the pond water would be extremely saline (over 30,000 mg/l TDS). The exact amount of seepage and its effect on Cow Creek water quality cannot be accurately estimated.

TDS levels in the alluvium of Hay Coulee adjacent to Area E and Pit 6 may remain slightly elevated for thousands of years due to spoils water discharge. However, the spoils discharges are so small that adverse effects are unlikely. Pony and Spring Creeks, which drain east and northeast out of Area D, will be largely unaffected by the mining in their headwaters, since most of the shallow groundwater moves southward toward Cow Creek.

The total effect of all mining activities on Rosebud Creek including the Big Sky Mine will be less than 1 percent increase in TDS levels. Industrial pond seepage may have a slight effect on the quality of water in Rosebud Creek.

3.2.3.1.2.3 Groundwater Use

Mining in the East Fork Armells Creek drainage from Colstrip will replace the Rosebud overburden and coal with a spoils aquifer. Shallow domestic water supplies from the overburden and coal will be irretrievably lost. Deeper aquifers exist that can be used to replace water supplies destroyed by mining, but the water quality may, in some cases, be of poorer

quality. Deeper wells would increase pumping costs, but the increases would be small. Spoils water could be used for stockwatering, although Western Energy proposes to replace lost wells with sub-McKay water, which generally has better quality than spoils water. (See Section 3.2.1.1.3.)

Continued expansion of the cone of drawdown created by mining will be the major impact on groundwater flow through the life of the Rosebud Mine and 100 years beyond. The area of influence is shown in Figures 3.2-2 and 3.2-3. Table 3.2-5 lists wells and springs that will be destroyed or affected during the life of the mine. Undoubtedly, as the cone of depression continues to expand following cessation of mining, additional wells and springs may be affected.

Groundwater use above Colstrip on East Fork Armells Creek will not be affected by mining because the water would still be usable for stockwatering, its only projected post-mining use. Below Colstrip in East Fork Armells Creek, mining would be part of a cumulative impact with industrial and municipal activities. The following paragraphs discuss the impacts of industrial and municipal activities on groundwater use near Colstrip.

Seepage from the existing fly ash evaporation pond could influence up to 15 private wells complete in the sub-McKay aquifer downgradient from the pond along East Fork Armells Creek. (See Figure 3.2-13.) Some of these private wells are used for domestic use. Degradation of water quality resulting from leakage of the industrial ponds and fly ash pond could restrict future water use from the shallow bedrock near Colstrip.

The existing and proposed industrial ponds located adjacent to the power plant will continue to degrade the McKay overburden, McKay coal, and possibly sub-McKay groundwater within a mile or two of them. No existing water supplies have been affected, but future potential sources of groundwater could be eliminated. As long as Yellowstone River water is available, the demand for alternative domestic water supplies in this area would be nonexistent. Should Yellowstone River water become unavailable, future domestic uses of shallow groundwater would be precluded long after the cessation of mining and industry.

The fly ash evaporation pond being built to receive wastewater from the Colstrip Power Units 3 and 4 would remove from usefulness one private stock well and one spring. Several private wells and at least one spring downstream from this pond could eventually be affected by seepage from this pond, although specifics of such possible changes are unknown.

In the long term, vegetative communities in the bottoms of East Fork Armells Creek, Cow Creek, and South Fork Cow Creek may shift in response to changes in water levels and increase in dissolved solids. Mining would not significantly affect water levels, but would contribute to the dissolved salt load. (See Section 3.2.3.1.2.)

3.2.3.2 Surface Water

This section addresses the impacts that all mining and mine-related development will have on the flow and quality of the surface-water system in the Rosebud Mine area.

3.2.3.2.1 Impacts Through 1987

3.2.3.2.1.1 Surface Water Flow

The effects of mining and industrial activities on East Fork Armells Creek would be different upstream than downstream from Colstrip. Upstream from Colstrip, only mining activities would affect the surface flow characteristics. Since a significant portion of runoff from precipitation events would be controlled by sediment ponds, the effect of mining would be to attenuate peak flows and lengthen periods of low flow. The same would be true of the headwater region of Stocker Creek in Area C. A very minor reduction in flow would occur due to evaporation of water held in the ponds.

Downstream from Colstrip, the effect of community and industrial activities would mask any mining-induced flow changes. Discharge from the sewage treatment plant and leakage from the surge pond, fly ash pond, and industrial ponds have created a marginally perennial stream downstream from Colstrip. The distance downstream that these discharges change the flow in East Fork Armells Creek is not known.

Mining and ponds associated with Power Units 3 and 4 will not noticeably alter the surface flow of Cow Creek because the water will remain in the groundwater system.

The new effect of mining activities on surface flow in the Colstrip area will be the slight attenuation of peak flows in Stocker Creek and East Fork Armells Creek upstream from Colstrip.

3.2.3.2.1.2 Surface Water Quality

The impacts from mining for the 5-year period on surface waters are described in Section 3.2.2.1.6. There will be no significant surface water quality deterioration from mining through 1987, but changes resulting from the industrial ponds will continue to affect East Fork Armells Creek during this period.

Seepage from the industrial ponds and surge pond plus the effluent from the sewage treatment plant exceeds the carrying capacity of the alluvium in the East Fork Armells Creek downstream from Colstrip and has forced some of this water to the surface. This additional water has created a fairly constant surface flow of about 0.5 cfs. Addition of poorer quality wastewater from the industrial ponds has caused an estimated increase of 500 to 1,500 mg/l in the TDS level of the surface flow. These increases will continue for decades to several hundred years after the ponds are abandoned and the groundwater mound dissipates. (See Section 3.2.)

3.2.3.2.1.3 Surface Water Use

Stockwatering, the only current surface water use in the Colstrip area, will not be affected because no grazing will occur in active mine

areas. Stock ponds destroyed by mining will be reconstructed during the reclamation phase. Irrigation or stockwatering uses would not change downstream from Colstrip.

3.2.3.2.2 Surface Water Impacts Through Life of Mine and 100 Years Beyond

3.2.3.2.2.1 Surface Water Flow

The cumulative surface-flow conditions described in the 5-year period would continue for the life of the mine and the generating station. The predicted changes in peak and annual flows that would occur as a result of mining would be small. (See Tables 3.2-6 and 3.2-7.) The surface-flow conditions would return to pre-mining conditions sometime after mining ceases.

The surface discharge of groundwaters recharged by the municipal/industrial developments will continue long after cessation of mining and power generation. The effect of the additional discharge will diminish slowly with time.

3.2.3.2.2.2 Surface Water Quality

The surface-water impacts from mining for the life of the mine and through 100 years are described in Section 3.2.2.2.1.

Upstream from Colstrip, mining will have little effect on the surface-water quality of East Fork Armells Creek. The only surface water, except for reaches that currently flow, will be stock ponds, sediment-control ponds, and precipitation-induced flow events. Since these are derived from surface runoff, and mine runoff is controlled by sediment ponds, mining will have little effect on surface-water quality of East Fork Armells Creek. Sections of the creek that receive alluvial groundwater inflow would experience higher TDS during low-flow conditions.

The effects on Stocker Creek will be similar to those described for East Fork Armells Creek.

Until the generating station is abandoned and the industrial ponds reclaimed, the surface water of East Fork Armells Creek downstream from Colstrip will have elevated TDS levels due to seepage of poor-quality industrial pond water into the valley fill system. Following reclamation of the ponds, the mound of poorer quality groundwater under them will continue to seep into the valley fill system for many decades and will contribute to higher levels of TDS in the stream. Mining influences on low-flow surface-water quality of East Fork Armells Creek and Cow Creek will continue for thousands of years.

Mining will probably have a slight effect on surface-water quality of Cow Creek. The small amount of spoils discharge (less than 10 gpm) is lost by evaporation and transpiration near the discharge zone and does not con-

tribute to surface flow. The only sources of surface water are stock ponds developed from springs and a dredged portion of the Cow Creek streambed. These appear to be recharged primarily from McKay coal or sub-McKay sandstones that will not be affected by mining.

Mining should not affect the surface waters of Spring and Pony Creeks because they are ephemeral streams. Mining would not affect a spring-fed stock pond located in Pony Creek.

Lee, Miller, Hay, and Coal Bank Coulees are ephemeral tributaries to Rosebud Creek, flowing only in response to precipitation events or snowmelt.

3.2.3.2.2.3 Surface Water Use

During the life of the mine, stockwatering, currently the only use of surface water, will not be affected because grazing is not permited on active mine areas. Stock ponds and springs destroyed by mining will be replaced either by windmill-pumped wells or by stock ponds. Other sources of stockwater, such as flowing reaches of East Fork Armells Creek that are destroyed by mining, will be replaced with wells completed in deeper aquifers.

If the surge pond is not maintained following cessation of mining and power generation, the quality of surface water downstream from Colstrip in East Fork Armells Creek could be affected because East Fork Armells Creek is perennially flowing. East Fork Armells Creek flow is maintained by bedrock and alluvial groundwater inflow. Degradation of alluvial water by mine spoils and industrial pond seepage could eventually affect the quality of surface water. The water could become unsuitable for stockwatering in ponded reaches for short periods of time in some years due to concentration of salts by evaporation. This effect may last for thousands of years.

Seepage from industrial and fly ash ponds could degrade surface water quality of Cow Creek and, in turn, impair stockwater use during certain times in some years. At the projected seepage rates, Cow Creek may suffer a slight degradation of surface water quality. Surface water uses in Stocker Creek and other tributaries to Rosebud Creek will not be affected by mining or nonmining activities at Colstrip.

3.2.4 Mitigations for Mining Impacts

Selective placement of saline overburden would reduce TDS level increases in spoils water. Selective placement of saline overburden, using a dragline, was done in Area B of Western Energy's Rosebud Mine. The saline material was placed above the bottom 20 to 30 feet of spoils, the zone that would become saturated with horizontally moving groundwater and below the rooting zone. An identical experiment involving the addition of a relatively impermeable clay cap on top of the saline material was also conducted. Because the Rosebut Mine appears to have a very low component of vertical recharge, the saline material was effectively isolated from the

groundwater system without the use of a clay cap. Selective placement of saline material increased direct operating costs by about 12 percent, whereas selective placement and clay capping increased costs by roughly 50 percent (Dollhopf et al., 1981, p. 79).

The degree to which selective placement of saline material on a mine-wide scale would reduce TDS in spoils waters has not been determined. Selective placement of saline material need only be done where overburden containing saline material exceeding suspect levels is identified. The frequency of occurrence and size of such saline pockets would have to be determined before an estimate could be made. Close review of existing lithologic logs and of overburden chemistry data, plus the possible need for additional drillholes, would be necessary to determine the extent of saline overburden zones. Even so, predictions of post-mining water quality with and without selective placement techniques would be very difficult and necessarily speculative.

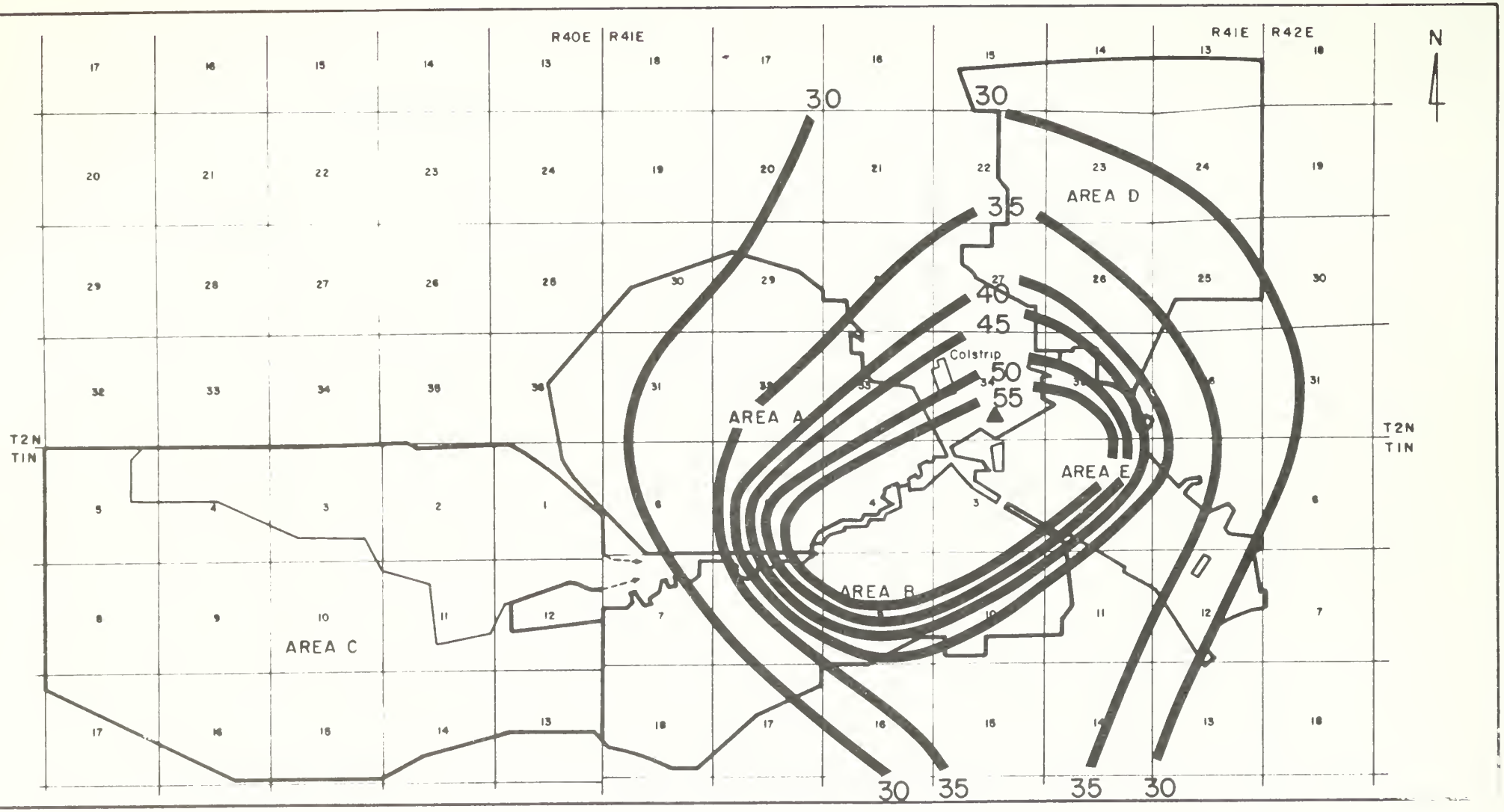


FIGURE 3.4-1 ISOPLETHS OF ANNUAL AVERAGE TSP CONCENTRATION, IN $\mu g/m^3$, RESULTING FROM 1980 SOURCES OF PARTICULATE MATTER IN COLSTRIP

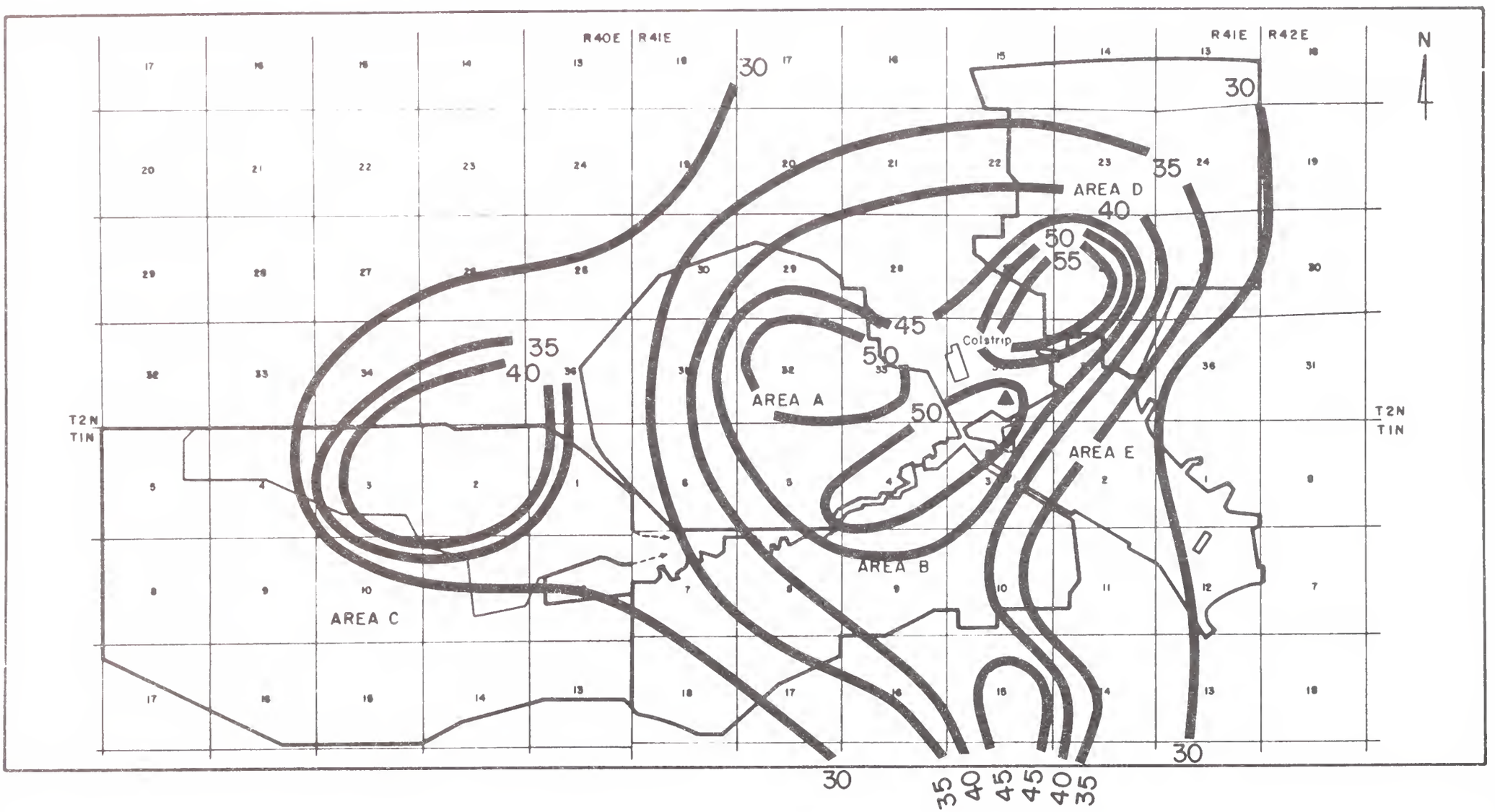


FIGURE 3.4-2 ISOPLETHS OF ANNUAL AVERAGE TSP CONCENTRATION, IN $\mu g/m^3$; RESULTING FROM 1988 SOURCES OF PARTICULATE MATTER IN COLSTRIP

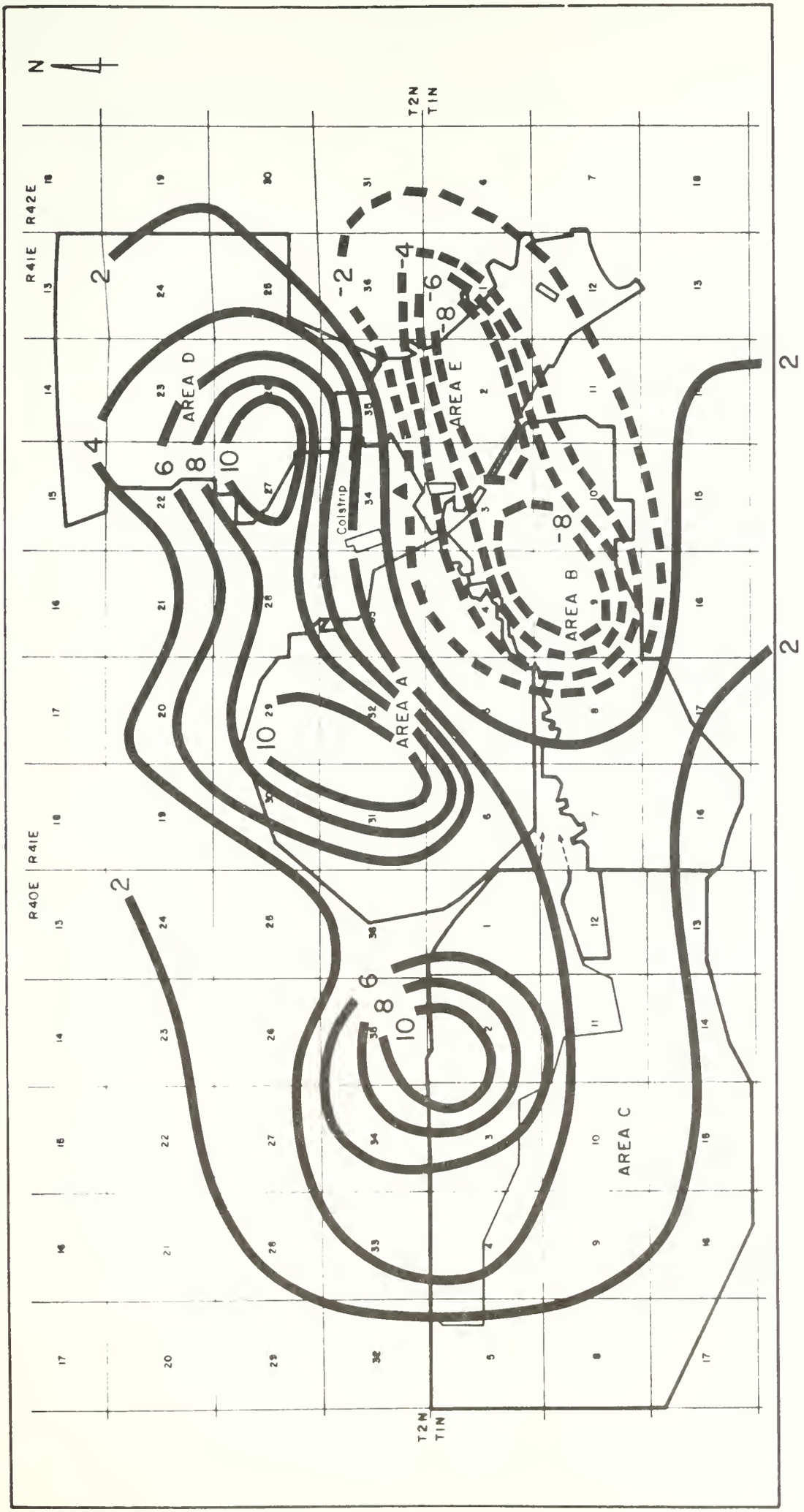


FIGURE 3.4-3 ISOPLETHS OF INCREASES IN ANNUAL AVERAGE TSP CONCENTRATION, IN $\mu g/m^3$, FROM 1980-1988 (DASHED LINES ARE DECREASES)

3.3 CLIMATE

Continued mining in the Colstrip area would not have any impact on the climatic regime in the area.

Four possible avenues for climatic modification were evaluated:

- Major increase in atmospheric moisture content
- Changes in surface albedo (light reflection from the Earth's surface) due to surface disturbance
- Changes in increasing radiation caused by increased suspended particulate matter
- Changes in cloud formation caused by increases in condensation nuclei (from suspended particulate matter)

The mine produces no major sources of atmospheric moisture. Increases from engine exhaust and evaporation of water used for dust suppression would be very small compared to moisture levels needed to produce climatic changes.

Very little disturbed acreage would differ significantly in color from the existing surface. Consequently, surface albedo would not be significantly altered by the project.

As documented in the visibility degradation analysis in the air quality section, suspended particulate concentrations would have little effect on light transmission. Thus no change in incoming solar radiation would be expected.

Finally, the particulate matter would stay close to the surface, where the availability of condensation nuclei is not the limiting parameter in cloud formations (Wallace and Hobbs, 1977).

3.4 AIR QUALITY

3.4.1 Impacts

A mining development can affect air quality in several ways:

- o It can increase the ambient concentrations of various pollutants in the air
- o It can increase the rate at which dust or other particulate matter settles on surfaces near the mining operation
- o It can degrade the ambient visibility in the area

To evaluate each of these effects the various project-related sources of air pollution emissions were inventoried and their emission rates were estimated. These estimates were then used, together with the meteorological data (Section 2.4), as input to a mathematical simulation model. The model estimated increases in ambient concentrations expected from the proposed project. From these concentrations, deposition and visibility degradation can be estimated.

Both the State and Federal Governments require that proposed new sources be evaluated for potential air quality impacts. Government agencies have established legal limits on pollutant levels (Table 2.4-1). An area of approximately 80,000 acres centered on the town of Colstrip has been designated a nonattainment area for TSP. Normally, new projects in such a location would be required to comply with the nonattainment provisions of the Clean Air Act amendments of 1977, which are now incorporated in Montana law. The Prevention of Significant Deterioration (PSD) requirements would not apply because of the nonattainment designation. The nonattainment regulations require that a source obtain an offsetting reduction in emissions equal to or greater than the proposed project emissions. Also, the new source is required to demonstrate that it will attain the lowest achievable emission rate (LAER). To be subject to the nonattainment review process of the Clean Air Act Amendments, a source must have at least 250 tons per year of nonfugitive emissions. Since mining produces mainly fugitive emissions, it is unlikely that any of the proposed mining operations would exceed this limit, and, thus, the nonattainment review does not apply. However, Section 16.8.1401 of the Montana Air Quality Rules still requires the LAER be attained.

The only pollutant of major concern would be particulate matter (TSP). By far, the most significant component of the particulate matter emission would be fugitive dust from heavy equipment movement on unpaved surfaces, and from coal and overburden handling. Major sources would include haul roads, draglines, wind erosion, scrapers, and bulldozers.

Although the crushing and conveying operations would be sources of dust, they are not "fugitive" sources, since control equipment would be installed on these units to reduce dust emissions.

TABLE 3.4-1

PARTICULATE MATTER EMISSIONS RATES

Source	Annual Emission Rate (tons/year) 1980	1988
Western Energy Sources	6,828	9,757
Peabody Big Sky Mine	1,502	2,426
Colstrip Units 1 and 2		
Stack Emissions	887	1,028
Lowering Wells	3	3
Crushing	1	1
Coal Piles	65	75
Colstrip Units 3 and 4		
Stack Emissions	0	3,582
Lowering Wells	0	6
Crushing	0	2
Coal Piles	0	15
Other Sources	2,927	3,169
TOTAL	12,213	20,064

Additionally, small amounts of particulate matter and gaseous pollutants would originate from the exhaust of diesel equipment. The most significant diesel pollutants would be oxides of nitrogen (NO_x). The increase in annual emissions of NO_x from 1980 to 1988 is estimated to be 637 tons from diesel equipment and an additional 110 tons from blasting with an ammonium nitrate and fuel oil mixture. This emission rate could be expected to increase ambient nitrogen dioxide (NO_2) concentrations in the project area by a small percentage, but impacts would be restricted to the mine areas. The increase in NO_x emissions from mining is small compared to the increase of 46,438 tons annually from the addition of Colstrip Units 3 and 4. Emissions of carbon monoxide (297 tons per year), hydrocarbons (47 tons per year), and sulfur dioxide (37 tons per year) would not constitute a significant impact on the region. Since these emissions would be small, and would not be likely to create any impact, only fugitive dust emissions are considered.

A summary of the emission inventory prepared by the air quality study team for the years 1980 and 1988 is shown in Table 3.4-1. Details of the computations can be found in the Technical Support Document. The years 1980 and 1988 were selected to represent current and future conditions. The year 1988 represents a period when mining will reach a peak level of activity. The peak will continue until 1997, when activity will decline to a significantly lower level.

In addition to the emissions caused directly by the project, secondary emissions would result from the increase in population and services accompanying the project and from other new projects in the area. (See Table 3.4-1).

The Ertec Mining Air Quality (EMAQ) model was used to predict ambient concentrations resulting from the emission rates presented above. The model is described in detail in the Technical Support Document. It is basically a Gaussian plume-based model that uses particle deposition based on the equations of Ermak (1977). Since long-term regional issues are most important in this EIS, the analysis of impacts has been restricted to annual average concentrations. The on-site meteorological data from the train loop station operated by Western Energy Company were used in the analysis. A full year of readings for the period of January through December 1980 was statistically analyzed.

The results of the air quality modeling study are presented in Figures 3.4-1 and 3.4-2 for 1980 and 1988. The results for 1980 are generally consistent with monitoring data for 1980. During 1980, the Western Energy sites with measured annual arithmetic mean concentrations greater than 55 micrograms per cubic meter ($\mu g/m^3$) (samplers WE1, WE2, WE3, WE4, and WE6) are all located within the 55 $\mu g/m^3$ isopleth in Figure 3.4-1. The 1988 results (Figure 3.4-2) show that concentrations would change from current conditions. This change is most easily visualized by plotting the differnce. Figure 3.4-3 is simply the 1988 results minus the 1980 results. The dashed isopleths represent areas where concentrations would decrease in the future. The solid lines represent areas of increased concentration.

As the figures show, concentrations in the Colstrip area would not change greatly as a result of future proposed mining. Close to mining operations (within 1,500 feet) one can expect significant changes (not shown in the figures), but these would be localized and highly variable. There are significant increases within the area classified as a nonattainment area for TSP.

The MAQB position regarding permitting in the nonattainment area is that an air quality permit for a specific source cannot be issued if it would cause or contribute to a violation of Montana or National Ambient Air Quality Standards, even though mining sources are generally not subject to review under the nonattainment regulations. Since the actual area where standards are exceeded is the town of Colstrip, the above criteria would apply if modeled emissions indicate a significant impact to the town of Colstrip. It should also be noted that each mining area or other source in the area will undergo its own review when it is proposed.

The area currently exceeds the federal primary standard for annual-average TSP concentrations (75 $\mu g/m^3$). The areas of violation are all located within the 55 $\mu g/m^3$ isopeth shown in Figure 3.2-1. As Figure 3.4-3 shows, this area is expected to decrease in concentration. However, other areas (vicinity of Area A and Area D) are expected to increase in concentration. Within 1,500 feet of the actual mining operation, the Federal TSP annual-average standard may be exceeded, but these impacts would be very localized.

The high concentrations have not produced a health hazard in the past, primarily because of the high percentage of large particles, which threaten health less than small particles. It is uncertain whether future particulate levels in Colstrip would constitute a health hazard.

While producing large TSP concentrations, fugitive dust does not pose as great a hazard to health as equivalent concentrations resulting from other sources. This is because much of the measured TSP in the fugitive dust comprises particles greater than 15 micrometers in mass mean diameter. These large particles are removed by nasal hairs and mucous membranes prior to entering the lungs during inhalation. No adverse health effects have been reported from exposure to annual geometric mean TSP concentrations of 86 $\mu g/m^3$ in Colstrip during 1974 through 1979 (Montana Department of Health and Environmental Sciences, 1980).

Deposition of particulate matter in the Colstrip area would follow the same pattern as concentrations. Values could be as high as 60 grams per square meter in the immediate area of the mining operation. Deposition levels in Colstrip are currently large, ranging from 7 to over 60 grams per square meter. The existing high deposition rate is expected to continue and to increase by significant amounts in the new mining areas (A, C, and D). Similarly, depositions would decrease in areas showing negative changes in concentration.

Visibility in the area would decrease slightly as a result of continued mining. Using the two lines of sight discussed in Section 2.4, the change in visual range was calculated for the 1988 mining activity. Along

line-of-sight number 1 (LOS1) visibility would decrease from 59.9 miles to 58.8 miles. Similarly, the visual range along LOS2 would decrease from 59.2 miles to 59.1 miles. These changes are below the detection limits of most instruments used to measure visibility degradation and would certainly not be detected by human observers. The insignificant changes are consistent with the behavior of fugitive dust. The relatively high percentage of large particles reduces the potential for visibility degradation, since large particles do not scatter light as effectively as small particles. Details of the computations and assumptions used in the visibility analysis are presented in the Technical Support Document.

The Northern Cheyenne Indian Reservation (NCIR) is accorded special visibility considerations due to its classification as Class I area. However, since air quality impacts in the NCIR from continued mining in Colstrip were calculated to be negligible, visibility degradation from the sources is expected to be negligible. For this reason, the existing visibility in the NCIR was not investigated.

3.4.2 Mitigations

Under the Montana Air Quality Rules, the lowest achievable emission rate (LAER) must be attained for the Area C mining operation. Therefore, any further mitigation measures would cause a negligible reduction in particulate emissions (Montana Department of State Lands and U.S. Office of Surface Mining, 1982, p. III-49, IV-14).

Enclosing the coal storage pile at the Area A and B, loudout would reduce particulate emmissions somewhat. However, the resultant reduction in total suspended particulate concentrations would be small.

3.5 NOISE

3.5.1 Impacts

The highest sound level at the mine due to equipment operation could be 98 dBA, if all equipment were operating in the same vicinity. In actuality, the mining equipment will be spread out over the area, and maximum sound levels will probably be lower.

Blasting noise due to the mining activities would also occur. Measured sound levels associated with blasting (Table 3.5-1) indicate the wide range of sound levels which could occur.

Without specific information describing topography, ground cover, meteorological conditions, source characteristics, and existing sound levels at the receptor location, changes in sound levels due to continued development of coal resources cannot be quantified. Nonetheless, the gradual divergence of mining activity from Colstrip will cause mine-related noise to affect an increasingly large area. With background levels as low as 29 dBA, intermittent blasting noise may be audible at great distances from the mine. Daily average noise levels in quiet areas would also be likely to increase due to the need for more workers and service industries and to more frequent train shipments. Sound levels in the community of Colstrip probably would not increase dramatically, since sound levels are already high.

3.5.2 Mitigations

Proper muffling and maintenance of equipment would minimize noise from mobile sources.

Noise from blasting could be mininimized by using the minimum necessary charges in the blast holes, adequate stemming, and covering the detonating cord.

Meteorological conditions affect sound propagation through the atmosphere. Noise from blasting can be reduced by postponing the blast if a temperature inversion exists at less than 5,000 feet and the affected community is downwind from the blast. Since inversions are frequently observed at night and during the first several hours after sunrise, special care should be taken during these hours. Also, noise can be reduced by postponing blasting when the affected community is downwind and the windspeed is greater than 15 mph.

TABLE 3.5-1

MEASURED SOUND LEVELS DUE TO BLASTING[a]

Type of Blast	Distance to Blast (feet)	Measured Maximum Sound Level (dBA)	Approximate Sound Level at 19,200 feet (dBA)[b]
Coal	1,500	79.0	57
Coal	8,000	66.1	58
Coal	8,000	65.7	58
Coal	5,000	80.4	69
Coal	5,000	83.1	71
Coal	6,500	74.9	65
Coal	6,500	75.0	65
Coal	11,700	55.5	51
Coal	12,500	60.2	56
Coal	20,500	55.4	56
Coal	12,400	66.1	62
Coal	17,000	75.3	74
Coal	23,000	54.5	56
Overburden	8,000	86.2	79
Overburden	16,000	65.2	64
Overburden	16,000	67.8	66
Overburden	18,500	57.2	57
Overburden	24,900	57.0	59
Overburden	13,000	62.1	59
Overburden	21,400	55.1	56

[a]Source: Foch and Oliver, 1980

[b]Attenuation due to divergence only; atmospheric absorption and ground cover attenuation are not included.

3.6 SOILS

3.6.1 Soil Handling Procedures

The analysis of anticipated soil impacts at the Rosebud Mine is dependent not only on the characteristics of the soils to be salvaged, but also on the methods that will be used in salvaging, handling and replacing soils. The soils at the Rosebud Mine have presented few serious limitations for reclamation to date. The major concerns have been salinity, as indicated by electrical conductivity, and sand and clay content. To identify soils where excessive salinity, sandiness, or clay may limit the use of salvaged soil, Western Energy has instituted a "presalvage soil sampling program." Soils that may exceed the accepted limitations are sampled and staked. This identifies the depths of acceptable topsoil and subsoil to be salvaged. Table 3.6-1 shows the general criteria used by Western Energy Company's soil specialists to determine topsoil and subsoil suitability and Table 3.6-2 shows the average salvage depths of suitable soil in the general soil groups at the Rosebud Mine. This same approach will probably continue to be used in future proposed mining areas.

Each major soil group has properties that influence the depths to which topsoil and subsoil can be salvaged. Table 3.6-2 shows the major limitations of each soil group and the general salvage depths now used in soil salvaging. The alluvial loamy and clayey soils would contribute the highest proportion of soil material for salvage, the unbaked shale and siltstone soils, the least.

As soils are salvaged, topsoil is handled separately from subsoil, allowing the replacement of each separately. Direct hauling is practiced wherever possible to retain microbial populations and plant parts in the soil.

Mining at the mine to date has concentrated in areas with alluvial loamy and clayey soils and sandy residual soil groups. In these areas, Western Energy has replaced up to 3 feet of subsoil and topsoil. In areas dominated by thinner, less well developed soils, such as those in the unbaked shale and siltstone group, less soil suitable for replacement may be available.

The impacts that can be anticipated in all mining areas would change the biological, physical, and chemical properties of the soils. Biological impacts would include a reduction in soil organic matter, microbial populations, and live plant parts. Topsoil salvaging would mix high-quality topsoil with less organic-rich lower topsoil layers. Where soils must be stored before replacement, a reduction and alteration in soil microbial populations can be expected, along with a decline in organic matter content and reproductive capability in roots and tubers.

Physical impacts could include 1) an overall increase in near-surface bulk density, which would influence soil infiltration and runoff, and 2) a reduction in the variability in the natural landscape. This reduction includes elimination of near-surface bedrock, commonly present in soils

Table 3.6-1

TOPSOIL AND SUBSOIL SELECTION CRITERIA (a)

Soil Parameter	Topsoil Cutoff (average for interval)	Subsoil Cutoff (average for interval)	Before Mining b	During Mining c
Texture (USDA triangle)	loamy sand silty clay, sandy clay, clay	sand, silty clay, sandy clay, clay	X	X
Moist Consistence	very firm extremely firm	very firm extremely firm	---	X
Electrical Conductivity	above 4 $\frac{\text{mmhos}}{\text{cm}}$	above 6 $\frac{\text{mmhos}}{\text{cm}}$	X	X
Sodium Adsorption Ratio	above 5	above 5	X	---
pH	less than 5.6 greater than 7.8	less than 5.6 greater than 7.8	X	---
Saturation Percentage	less than 25% greater than 80%	less than 25% greater than 80%	X	---
Boron	above 8 ppm	above 8 ppm	X	---

(a) Based upon recommended soil criteria suggested by Schaefer (1978), revised by WEC's soils staff to reflect conditions at the Rosebud Mine.

(b) Before mining begins, representative samples are collected for each soil series, averaging two soil sampling sites per soil series in each mine area.

(c) During mining multiple samples are collected for most soils just prior to salvaging and analyzed.

Table 3.6-2

CHARACTERISTICS OF GENERAL SOIL GROUPS,
ROSEBUD MINE

Soil Group	Limitations	Proposed Salvage Depth Topsoil (feet)	Subsoil (feet)
Alluvial Loamy and Clayey Soils	High salts in subsoil, occasional high clay	1.0	0.5-3.5
Sandy Residual Soils	Excess sand, depth to rock	0.5	1.0-2.5
Clinker Soils	Depth to fractured rock, excess coarse fragments, slope	0.5	1.0-1.5
Unbaked Shale and Siltstone Soils	High salts, depth to rock, high clay, slope	0.5	0-2.5

along ridges and hills. Large discrete areas of soils would be replaced by locally variable soils, reducing the variability of soil microenvironments and resulting in more uniform vegetation on reclaimed soils.

Chemical impacts would include a modification of the extremes of salt contents in the soil. The wide range of soil salinity that occurs naturally would not be replaced. The replaced soils and spoil would take a considerable time to reestablish natural patterns of salt deposition. Other chemical constituents found naturally, including nickel or molybdenum, may be found in isolated patches within the rooting zone after regrading.

3.6.2 Area A

The total area to be disturbed by boxcut spoils and highwall reduction in Area A represents more land than would be disturbed by mining. Of the 3,184 acres not yet disturbed, 1,185 acres would be disturbed by mining and 1,444 acres by boxcut spoils and highwall reduction. The high proportion disturbed by boxcut spoils and highwall reduction zones stems partly from the mining sequence necessitated by high overburden in the center of Area A.

The high component of unbaked shale and siltstone soils in the unmined part of Area A indicates that soil for salvage may be limited in some mining passes and will require careful control to avoid shortfalls. The characteristics of the soil group strongly influence the soil available for salvage. For example, the alluvial loamy and clayey soils have yielded from 1.5 to 4.5 feet during previous salvaging, while the unbaked shale and siltstone soils have contributed significantly less, ranging from 0.5 to 3.0 feet. (See Table 3.6-2)

Table 3.6-3 shows soil distribution by category of disturbance. In general, soil shortfalls are most likely in boxcut spoil and highwall reduction areas, because of the high component of clinker and unbaked shale and siltstone soils in these areas.

Areas previously mined in Area A supported a diverse agricultural base, including range grazing, pasture, and cropland. With mining, discrete areas of alluvial loamy and clayey soils have been replaced with a patchy distribution of both loamy and sandy soil types. This has probably reduced the potential for successful crop production.

The major impact unique to Area A would be the high percentage of land to be disturbed by boxcut spoils and by highwall reduction. The potential for soil shortfalls is exacerbated by the need to salvage soil from and reclaim these areas in addition to the mined area.

Several alternatives are available to reduce the land area disturbed by mining Area A. One alternative would be to leave the highwall standing in portions that are logical extensions of existing bluffs or cliffs. A second alternative, which would eliminate or reduce the boxcut spoil disposal area and highwall reduction zone, would be to use the boxcut spoils

Table 3.6-3

SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA A

	Mine Area	Boxcut Spoils and Highwall Reduction Area	Undisturbed	Total
Sandy Residual Soils	145 acres	117 acres	10 acres	272 acres
Alluvial Loamy and Clayey Soils	432 acres	372 acres	289 acres	1,093 acres
Clinker Soils	79 acres	270 acres	114 acres	463 acres
Unbaked Shale and Siltstone Soils	529 acres	685 acres	142 acres	1,356 acres
TOTAL	1,185 Acres	1,444 Acres	555 Acres	3,184 Acres

to fill the final highwall area. This would largely confine the disturbance to mined areas, with some temporary disturbance to boxcut spoils holding areas.

A third alternative would be to open the boxcut in four segments. Western Energy would cast out boxcut spoils for the first segment and then haul or cast the boxcut spoils from the second, third, and fourth units to the previous segment.

3.6.3 Area B

The distribution of soil groups in Area B is similar to what has been encountered previously by Western Energy. The preponderance of alluvial and sandy soils indicates that no shortages of suitable replacement soil material would occur (See Table 3.6-4). The few areas of conifers occur on the unbaked shale and siltstone soil group. As elsewhere, additional soil handling measures to encourage conifer survival may be necessary.

3.6.4 Area C

One of the major soil impacts anticipated in Area C is increased compaction. This is of concern throughout the mine but is most likely to restrict root growth in Area C, especially in the alluvium of East Fork Armells Creek. Although the creek will be diverted from the mined area, the predominantly silty and clayey soils will probably retain moisture for some time. The moisture and the soils' fine texture will increase the soils' tendency to form compacted layers when handled. To mitigate this, it may be necessary to monitor the bulk density of subsoils and topsoils as they are laid down and to perform multiple deep ripping.

In Area C, 1,471 acres, nearly 18 percent of the area, is currently used for crop or hay production. This allows for a diversification of agricultural products important to local ranches.

At present, cropland covers almost exclusively the alluvial loamy and clayey soils. The acreage of each soil type and the anticipated disturbance are shown on Table 3.6-5. The loamy and clayey textures of these soils reduce deep infiltraton and hold soil moisture in near-surface layers, where most annual crops have their roots. Conversely, on sandy soils, deep infiltration occurs, reducing near-surface moisture and limiting cropping success.

Reclamation with present methods would intermingle patches of loamy and sandy soils, significantly reducing the potential for crop production.

The restoration of areas with cropping potential after mining would require the selective placement of medium- to fine-textured soils on the larger, gently rolling portions of the post-mine landscape. This would restrict the placement of soils from the sandy residual, clinker and most of the unbaked shale and siltstone groups. A well-planned and implemented soil salvage program would be required. Western Energy is now selectively

TABLE 3.6-4

SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA B

	Mine Area	Boxcut Spoils and Highwall Reduction Area	Undisturbed	Total*
Sandy Residual Soils	760	180	46	986
Alluvial Loamy and Clayey Soils	947	336	114	1,397
Clinker Soils	-	49	9	58
Unbaked Shale and Siltstone Soils	75	177	342	594
TOTAL	1,782	742	511	3,035*

* 213 acres in Area B have been previously mined and reclaimed and are not included in these figures.

TABLE 3.6-5

SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA C

	Mine Area	Boxcut Spoils and Highwall Reduction Area	Undisturbed	Total
Sandy Residual Soils	1,684	492	69	2,245
Alluvial Loamy and Clayey Soils	2,609	1,383	444	4,436
Clinker Soils	83	212	65	360
Unbaked Shale and Siltstone Soils	664	549	78	1,291
TOTAL	5,040	2,636	656	8,332

handling and placing sandy soils, which could be coordinated with current soil salvage and placement practices.

3.6.5 Area D

Area D may undergo impacts additional to those discussed for other areas because of the extensive stands of ponderosa pine.

Soil placement to encourage landscape stability will be important in reclamation. Portions of watersheds supplying Cow Creek, Pony Creek, Spring Creek, and East Fork Armells Creek extend into Area D. To avoid altering streamflow patterns, reclamation will have to include the replacement of watershed divides.

Sandy soils are concentrated in the gently sloping portions of Area D to be mined in the first 5 years. This is an area of few drainages or steep slopes; thus, replacement of sandy soils in these areas is not expected to be a major problem.

The soils in the center of Area D, which would be disturbed from year 15 until the completion of mining, are dominated by the unbaked shale and siltstone soil group. As shown in Table 3.6-2, the soils in this group can be expected to yield moderate to low amounts of usable soil material. A variety of soil limitations occur in this group: bedrock at shallow depths, high electrical conductivity (salinity), high clay content, or excessive rock contents. A detailed presalvage sampling program will be necessary to obtain sufficient soil material for reclamation. To obtain sufficient soil for reestablishment of grassland vegetation, it may also be necessary to use soils stockpiled from other portions of Area D.

The soils of the post-mined surface would probably not support vigorous, self-regenerating stands of ponderosa pine similar to the stands now in Area D. Soils in which rapid infiltration can occur, including soils of the sandy residual unbaked shale and siltstone and the clinker groups, would be reduced unless special soil salvage procedures were implemented (Table 3.6-1). Weathering and mechanical disruption would increase the clayey and loamy components of the unbaked shale and siltstone soils, making these soils similar to the alluvial loamy and clayey soil group. Bedrock layers, important in accumulating water along contacts and fracture zones, would be disrupted. Thus, soils that currently give competitive advantage to ponderosa pine trees in Area D would be largely lost in the reclaimed areas and replaced by soils similar to those supporting grassland communities unless special salvage and spoil treatment procedures are employed.

To aid ponderosa pines, several techniques could be used to encourage rapid infiltration into soils and accumulation of water along relatively impermeable soils layers, similar to accumulation along bedrock layers. Selective placement of sandy or clinker soils in thick, undifferentiated subsoil and topsoil layers would keep the soils highly permeable and encourage rapid infiltration. Water accumulation along the soil/overburden contact would then be encouraged if the overburden were not ripped. Since

soil compaction would defeat these measures, machinery traffic over the soil should be minimized.

Clinker soils are the most easily adapted for use as a specific ponderosa pine site soil. Unfortunately, most clinker soils in Area D will be left undisturbed until almost the completion of mining during the highwall reduction phase. (See Table 3.6-6) Therefore, it may be necessary to identify alternative sources of soils within Area D that would encourage survival and regeneration of ponderosa pine, including utilizing clinker soils earlier in the mining sequence.

Some old spoils from Northern Pacific's mining operation are included within Area D. These would be used for some mining-related activities. The spoils would be regraded to conform with the surrounding topography; excess topsoil and subsoil material, if available, would be spread on the regraded old spoils; the surface would be revegetated. The reintegration of the old spoils with the surrounding landscape would be a positive impact of mining.

3.6.6 Area E

Area E is a relatively small mine area with only about 2 years of mining remaining. The soils in the area are predominantly sandy and alluvial loamy and clayey (See Table 3.6-7). These soils are expected to undergo the same impacts found throughout the mine. Some areas of old spoils will be regraded and reclaimed. This would be a positive impact.

3.6.7 Mitigations

Several alternatives are available to reduce the land area disturbed by mining Area A. One alternative would be to leave the highwall standing in portions that are logical extensions of existing bluffs or cliffs. A second alternative, which would eliminate or reduce the boxcut spoil disposal area and highwall reduction zone, would be to use the boxcut spoils to fill the final highwall area. This would largely confine the disturbance to mined areas, with some temporary disturbance to boxcut spoils holding areas.

A third alternative would be to open the boxcut in four segments. Western Energy would cast out boxcut spoils for the first segment, and then haul or cast the boxcut spoils from the second, third, and fourth units to the previous segment.

The restoration of areas with cropping potential after mining would require the selective placement of medium- to fine-textured soils on the larger, gently rolling portions of the post-mine landscape. This would restrict the placement of soil from the sandy residual clinker and most of the unbaked shale and siltstone groups. A well-planned and implemented soil salvae program would be required. Western Energy is now selectively handling and placing sandy soils, which could be coordinated with current soil salvage and placement practices.

TABLE 3.6-6

SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA D

	Mine Area	Boxcut Spoils and Highwall Reduction Area	Undisturbed	Total*
Sandy Residual Soils	736	228	146	1,110
Alluvial Loamy and Clayey Soils	361	238	153	752
Clinker Soils	56	291	198	545
Unbaked Shale and Siltstone Soils	751	192	13	956
TOTAL	1,904	949	510	3,363

* Does not include 273 acres of old Northern Pacific Spoils.

TABLE 3.6-7

SOIL DISTRIBUTION BY PROPOSED DISTURBANCE, AREA E

	Mine Area	Boxcut Spoils and Highwall Reduction Area	Surface Disturbance	Total*
Sandy Residual	187	41	46	274
Alluvial Loamy and Clayey Soils	105	31	50	186
Clinker Soils	-	-	19	19
Unbaked Shale and Siltstone Soils	17	15	109	141
TOTAL	309	87	224	620*

* Does not include 805 acres of old spoils or 471 acres of land previously mined and reclaimed.

To aid in the reestablishment of ponderosa pines, several techniques could be used to encourage rapid infiltration into soils and accumulation of water along relatively impermeable soils layers, similar to accumulation along bedrock layers. Selective placement of sandy or clinker soils in thick, undifferentiated subsoil and topsoil layers would keep the soils highly permeable and encourage rapid infiltration. Water accumulation along the soil/overburden contact would then be encouraged if the overburden were not ripped. Since soil compaction would defeat these measures, machinery traffic over the soil should be mininimized.

Clinker soils are the most easily adapted for use as a specific ponderosa pine site soil. Unfortunately, most clinker soils in Area D will be left undistrubed until almost the completion of mining during the highwall reduction phase. (See table 3.6-6.) Therefore, it may be necessary to identify alternative sources of soils within Area D that would encourage survival and regeneration of ponderosa pine, including utilizing clinker soils earlier in the mining sequence.

ponderosa pine seedlings; (3) the direct seeding of ponderosa pine produces limited success; (4) root emergence does not appear to be a problem with auger-planted nursery stock; (5) planted stock naturally develops symbiotic associations with fungi; and (6) collecting seed from a few trees (6-7) within a few different pine stands (3-4) would probably represent the genetic diversity of the population.

Stark, in her ponderosa pine research, assessed soils in natural conditions and compared them with replaced spoils. She found that, in terms of soil pH, osmotic potential, soil surface temperature and light, reclaimed sites are suitable for ponderosa pine germination at least in spring. Stark found further that (1) an acid medium of about pH 6 produced best growth, although pH 8 produced suitable growth; (2) a topsoil sewage-compost medium produced the best growth; (3) seedlings in heavy textured soils grew best with less frequent watering--shorter frequency watering retarded the development of fungal associations; (4) manganese concentrations between 40-80 ug/g were detrimental to seedling development; (5) calcium concentrations greater than 4,000 ug/g became detrimental to seedling development; and (6) altered ratios of 5 ug/g iron to 5 ug/g manganese encourage very good growth (but do not fit field conditions).

Stark found physical, chemical, and microsite differences between regraded spoils and natural soils. The most significant problem after mining may be compaction of spoils and topsoil. One condition she found important to pine growth is surface and subsurface rock, which bars the downward percolation of moisture.

Running's work on ponderosa pine was associated with abiotic environmental conditions, primarily heat, water, and cold stress on seedlings. He recommended (1) microsites with north aspect plantings, (2) water harvesting (rainfall cups to direct water to seedlings), (3) rock mulching the surface to reduce soil surface water evaporation and (4) herbicide application to reduce competition with other species. Another factor being investigated is seedling hardening (or stress cycling).

In addition to the difficulty of establishing ponderosa pines, an impact common to all areas would be a shift in the composition of vegetative types. Western Energy Company is not proposing to reestablish the exact acreage of each type now present. Thus, in general, each area will have more grassland and less conifer-shrubland and shrubland-grassland. Revegetation plans and seed mixtures have been proposed by Western Energy Company for portions of each mine area (Appendix C). As permit applications are submitted, specific detailed revegetation plans will be developed that reflect up-to-date technology.

Currently, the revegetation plan calls for the establishment of non-competitive grasses, forbs, and shrubs in a first phase of seeding, with the more competitive cool-season grasses interseeded into the first phase planting after a period of 1 to 3 years. In addition to the woody species included in the seed mix or regenerated from direct-hauled topsoil, locally adapted trees and shrubs will be transplanted from undisturbed areas or planted as tubelings into designated areas.

3.7 VEGETATION

Of a total of 21,626 acres in the Rosebud Mine, 16,078 would be disturbed by Western Energy's operation, including 10,220 by mining and 5,858 by boxcut spoil deposition, highwall reduction, and facilities. The vegetation on the 16,078-acre disturbance area would be temporarily destroyed. This would not take place all at once, however. The vegetative cover would be removed in stages, as mining progresses. Reclamation would follow, usually beginning within 5-6 years of initial soil stripping.

Most impacts to vegetation would end upon reclamation. However, prolonged soil impacts from mining may alter the potential for reestablishing climax communities that may have been reached before mining. A mozaic of soil textures and depths that exist now over the mine area would be replaced during reclamation with more homogeneous mixtures, as a result of replacing separately the topsoil, subsoil, and overburden. Further, despite the positive effects of direct topsoil haulage, organic matter content is expected to decrease. Thus, after mining "rangesites," infiltration rates and moisture holding capacities may be different from conditions before mining.

These soil changes, which would be further exacerbated in areas reclaimed with stockpiled soils, would additionally cause decreases in the number of distinct plant communities, the overall distribution of warm-season species, and the total number of species.

With time, however, species diversity will increase, as reclaimed areas are invaded by natural seed. The rate of invasion and recovery will depend on (1) the proximity of reclaimed areas to undisturbed areas (a source of seed), (2) the seed dispersal mechanisms of individual species, and (3) the availablity of suitable microsites.

In contrast to diversity, post-mining forage production, particularly for livestock grazing, is expected to reach or exceed pre-mining levels. This assumes proper management, good weather conditions, and the ability of Western Energy to avoid making root-inhibiting compacted layers during regrading. During the first several years, annual grasses and weedy species would dominate; however, within 5 to 10 years after final seeding, species associated with higher forage production (i.e., perennial grasses) would probably assume dominance.

Some vegetative types will require more research and special procedures to reestablish--pondersoa pine stands in particular. To date, efforts to reestablish conifers on regraded spoil and scraper-hauled soils at Colstrip have not been successful enough to indicate that stands of trees with densities equivalent to pre-mine conditions can be established. However, recent research at Colstrip by George Blake, Nellie Stark, and Steve Running from the University of Montana has revealed new information on this problem.

Blake, studying natural regeneration of ponderosa pines, has found that (1) most seedling mortality can be attributed to rodent predation; (2) cool-season, herbaceous cover competes with and can influence the growth of

The success of revegetation efforts takes several years to judge. Areas that have been reclaimed using the two-phase seeding approach are recent (1981 and 1982), and it is too early to evaluate the success of this technique. A study started in 1977, however, has shown positive results for establishment of native plant species using both broadcast and drill-seeding techniques (DePuit et al., 1980). The study area indicates that a protective cover of vegetation can be established on the post-mine area with forage productivity higher than pre-mine levels.

Each mine area possesses a distinct combination of topography (slopes, aspect, etc.), soils, geology, grazing patterns, and microsites that influence vegetative cover. A discussion of individual areas follows.

3.7.1 Area A

Area A lies in the north-central part of the Rosebud Mine. The most prevalent vegetation type in the undisturbed parts of the area is the conifer-shrubland type, which occurs along ridges. After mining, the area would be rolling and grass-covered, with relatively simple topography and a limited distribution of shrubs or conifers (Table 3.7-1).

More than half of the area proposed for disturbance in Area A would be disturbed by boxcut spoiling and highwall reduction. Two ways to limit the area of disturbance would be (1) to reduce the need to dispose of boxcut spoils outside the mined-out areas and (2) to use boxcut spoils for a part of highwall reduction.

3.7.2 Area B

Area B is a rolling area dominated by grassland and shrub-grassland with a few areas of conifer-shrubland in the southernmost portion. Table 3.7-2 compares the existing vegetation of the undisturbed portion of Area B with the proposed post-mine vegetation. Shrubland areas would decrease slightly after mining, but the general proportions of the vegetative types are similar for the pre- and post-mine landscapes. A large area of disturbed grassland in the center of Area B will be replaced with a diverse native plant cover. This may reduce the availability of early spring forage for the area but might provide more stable long-term cover.

3.7.3 Area C

Table 3.7-3 shows the acreage of existing vegetation versus the proposed revegetation types after mining for Area C. There would be a significant drop in shrub-grassland and conifer-shrubland types, with a corresponding increase in grassland. The diversity of agricultural productivity in the area would be significantly reduced by the elimination of 1,309 acres of cropland. The potential for cropland would also be reduced by the mixing of sandy and loamy soil types during replacement. Post-mining soils are expected to be more droughty than pre-mining soils.

Under the existing plan, mining in Area C would eventually move through a part of East Fork Armells Creek. A small amount of riparian

Table 3.7-1

EXISTING AND EXPECTED POST-MINED VEGETATION, AREA A[a]

Existing Vegetation to be Disturbed	TOTAL (acres)		Proposed Revegetation Type
Grassland	780	1,739	Upland, Steep Upland Seed Mix
Shrub-Grassland	1,091	172	Lowland Drainage Mix Upland seed mix with shrub tubelings (Big Sage, Silver Sage, Skunkbush Sumac, Rubber Rabbitbrush)
Conifer-Shrubland	584	182	Conifer Zone Seed Mix
Cropland	125	-	
Disturbed Grassland	49	-	
	-	772	Unspecified (by Western Energy)
Current Surface Disturbance	236	-	
	2,865[a]	2,865[a]	

a. Includes only acreage proposed to be disturbed. Areas that will not be disturbed, or that have been previously reclaimed, are not shown. Total acreage in Area A is 4,324 acres.

Table 3.7-2

EXISTING AND EXPECTED POST-MINED VEGETATION, AREA B[a]

Existing Vegetation to be Disturbed	TOTAL (acres)		Proposed Revegetation Type
Grassland	1,238	1,660	Upland, Steep Upland Seed Mix
Shrub-Grassland	779	536	Lowland Drainage Mix Upland mix with shrub (Big Sage, Silver Sage, Skunkbush Sumac, Rubber Rabbitbrush)
Conifer-Shrubland	88	184	Conifer Zone Seed Mix
Cropland	116	-	
Disturbed Grassland	303	-	
	-	334	Unspecified (by Western Energy)
Current Surface Disturbance	190	-	
	2,714[a]	2,714[a]	

a. Includes only the acreage proposed for disturbance. Areas that will not be disturbed, or that have been previously reclaimed, are not shown. The total acreage in Area B is 3,438 acres.

Table 3.7-3

EXISTING AND EXPECTED POST-MINED VEGETATION, AREA C[a]

Existing Vegetation to be Disturbed	TOTAL (acres)		Proposed Revegetation Type
Grassland	3,130	5,998	Upland, Steep Upland Seed Mix
Shrub-Grassland	2,624	658	Lowland Drainage Mix Upland mix with shrub (Big Sage, Silver Sage, Skunkbush Sumac, Rubber Rabbitbrush)
Conifer-Shrubland	482	127	Conifer Zone Seed Mix
Cropland	1,309	-	
Disturbed Grassland	131	-	
	-	893	Unspecified (by Western Energy)
	7,676[a]	7,676[a]	

a. Includes only the acreage proposed for disturbances. Areas that will not be disturbed, are not shown. The total acreage in Area C is 8,332 acres.

habitat would be lost. The duration of the impact would depend on the condition of the hydrologic balance, that is, the length of time required to recharge the system and the adequacy and availability of moisture to support riparian vegetation. Western Energy has proposed using transplant techniques to obtain riparian revegetation. The effect that disruption of the hydrologic balance would have on downstream riparian vegetation has not yet been determined.

3.7.4 Area D

Area D suports the highest proportion of conifer-shrubland vegetation in the Rosebud Mine. Nonetheless, little of the post-mine area would be planted with ponderosa pine, according to Western Energy's reclamation plans. Further, the survival rate of planted pines is uncertain. Mining in Area D is therefore expected to result in the long-term reduction of ponderosa pine (Table 3.7-4).

The work on ponderosa pine discussed earlier, plus work completed by Stark (1982), Richardson (1980), and Branson (1982), indicates that to reestablish ponderosa pine, Western Energy would have to (1) reduce predation by rodent populations, (2) provide a rocky surface and subsurface soil, (3) keep competition from grasses low, (4) provide relatively loose soils, ideally with bulk densities less than 1.3 g/cm^3, (5) provide soils or rock with low permeability at moderate depths (20-50 inches) in the rooting medium, (6) provide soils with limited alkalinity or calcereousness, and (7) limit grazing in newly planted stands. It is likely that some of these factors will emerge as being important for reestablishment as research continues. According to Western Energy's plan, reestablishment of conifer stands in Area D would not occur until the last 5 years of mining. This would allow approximately 20 years for further research on conifer establishment, which will increase the likelihood of successful replacement of pines.

The numerous watershed divides in Area D would dictate the reconstruction of a complex rolling topography. Due to patterns of snow accumulation and runoff, the post-mine portions of the area D would probably evolve with some discrete plant communities.

The preliminary revegetation plan for Area D shows shrubland plantings on many of the steeper reconstructed hills. As the post-mine plant communities reestablish themselves, some of these areas can be anticipated to prosper, while others, due to subtle microsite differences that cannot be predicted, may gradually die out. Planted shrubs, regardless of long-term survival, will serve as seed sources, allowing establishment of shrubs in adapted microsites.

Approximately 273 acres of spoils left by Northern Pacific operations are included in Area D. These areas will be used for some boxcut spoil placement, roads, and some facilities. After mining, the old spoils would be regraded to blend with the surrounding landscape, covered with a layer of soil, and revegetated. Thus, mining in Area D would result in the reclamation of currently unreclaimed areas.

Table 3.7-4

EXISTING AND EXPECTED POST-MINED VEGETATION, AREA D[a]

Existing Vegetation to be Disturbed	TOTAL (acres)		Proposed Revegetation Type
Grassland	1,122	1,391	Upland, Steep Upland Seed Mix
Shrub-Grassland	455	291	Lowland Drainage Mix Upland mix with shrub (Big Sage, Silver Sage, Skunkbush Sumac, Rubber Rabbitbrush)
Conifer-Shrubland	1,135	222	Conifer Zone Seed Mix
Cropland	141	-	
Disturbed Grassland	-	-	
	-	949	Unspecified (by Western Energy)
Old Spoils	273	273	Reclaimed Old Spoils (reclamation technique to depend on availability of excess topsoil as mining is completed.)
	3,126[a]	3,126[a]	

a. Includes only the acreage proposed for disturbance. Areas that will not be disturbed, are not shown. The total acreage in Area D is 3,636 acres.

3.7.5 Area E

The undisturbed portion of Area E is small and dominated by the shrub-grassland type. A large portion of Area E is made up of spoils left by Northern Pacific. As shown in Table 3.7-5, post-mine Area E will include more grassland and slightly more conifer-shrubland type acreages than before mining. Conversely, the acreage of shrub-grassland habitat type will be reduced. The portion of the Northern Pacific spoils will be regraded and blended with the surrounding topography. Because of this, the impacts of mining in Area E will be positive.

3.7.6 Conveyor Corridor

Of the 4.1 miles crossed by the corridor, 1.4 miles include undisturbed grassland vegetation and 0.7 mile of alfalfa field. The remaining 2.0 miles fall within areas previously disturbed by Rosebud Mine activities (1.5 miles) or by Northern Pacific mining. The major impacts anticipated to result from the corridor will stem from the footings of the conveyor, the road base across the alfalfa field, and the disruption of vegetation during conveyor construction and maintenance.

3.7.7 Mitigations

Vegetation disturbance in Area A could be limited by (1) reducing the need to dispose of the boxcut spoils outside the mined-out areas, and (2) using boxcut spoils for a part of the highwall reduction.

To increase the chances of reestablishment of ponderosa pine, Western Energy could implement some or all of the following factors:

- Reduce predation by rodent populations.
- Provide a rocky surface and subsurface soil.
- Keep competition from grasses low.
- Provide relatively loose soils with bulk densities of less than 1.3 grams per cubic centimeter.
- Provide soils or rock with low permeability at moderate depths in the rooting medium (20 to 50 inches).
- Provide soils with limited alkalinity.
- Limit grazing in newly planted stands.

Table 3.7-5

EXISTING AND EXPECTED POST-MINED VEGETATION, AREA E

Existing Vegetation to be Disturbed	TOTAL (acres)		Proposed Revegetation Type
Grassland	89	300	Upland, Steep Upland Seed Mix
Shrub-Grassland	416	42	Lowland Drainage Mix Upland mix with shrub (Big Sage, Silver Sage, Skunkbush Sumac, Rubber Rabbitbrush)
Conifer-Shrubland	52	54	Conifer Zone Seed Mix
Cropland	0	-	
Disturbed Grassland	63	-	
	-	695	Unspecified (by Western Energy)
Old Spoils	805	805	Reclaimed Old Spoils and permanent facilities
Currently Under Reclamation	471	-	
	1,896	1,896	

3.8 WILDLIFE

Important impacts generally stem from disturbance of valuable habitats or land features. The most valuable habitat and features of the Rosebud Mine include: 1) the prominent sandstone outcrops/cliffs that have served in the past as nesting habitat for several raptors, including the golden eagle and prairie falcon; 2) traditional sharp-tailed grouse dancing grounds; 3) the conifer-shrubland habitats, which provide nesting sites, forage, and shelter; 4) perennial and seasonal sources of surface water and 5) the small patches of riparian habitat along East Fork Armells Creek.

Rock outcrops for cliff-nesting raptors are widely available in the study area, including Areas A, C, and D. The comprehensive mine plan calls for destroying the prominent rock outcrop in Area C, where a golden eagle nest and a prairie falcon nest are located. The U.S. Fish and Wildlife Service has recommended that the sandstone outcrop not be destroyed.

There are three sharp-tailed grouse dancing grounds in Area C and one in Area A that would be disturbed by mining operations. Although dancing grounds are traditional breeding sites, receiving use over many years, it is not known how critical the preservation of such sites is to the welfare of grouse populations. Some evidence suggests that sharp-tails do occasionally establish new dancing grounds. Western Energy has been conducting studies of grouse dancing-ground establishment for several years and has committed to continuing its sponsorship of studies aimed at mitigating mining impacts on grouse. Since ultimate success of sharp-tailed grouse dancing ground relocation efforts is not predictable, destruction of dancing grounds could have regional importance to sharp-tailed grouse populations.

Conifer-shrubland habitats are difficult to reestablish and would be lost to wildlife for many years. The extent of the area loss is discussed in Section 3.7. This loss would, in particular, adversely affect mule deer and birds needing conifer stands for food, cover, and nesting habitat.

Stock ponds will be replaced during reclamation. It is expected that wildlife species will use surrounding water sources during mining. The impact from this temporary loss is expected to be minimal.

The shrubby stands along East Fork Armells Creek would be lost during mining, causing displacement of more mobile species during mining and destruction of nonmigratory species with home ranges confined to the mining area. Riparian habitat is important to wildlife, providing niches for species that otherwise would not occur in the area. Its areal extent along East Fork Armells Creek is limited. Thus the impact to wildlife from the destruction of this habitat type is not expected to be significant regionally. The riparian areas are expected to regenerate after reclamation, although this may take decades.

Most of the area to be disturbed by mining includes the grassland and shrub-grassland habitat types used by a variety of wildlife. The reclamation plan would alter the proportions and composition of habitat types substantially. The dramatic increase in grassland habitat after mining

would benefit grassland bird and mammal species. However, the reduction of shrubland and, especially, conifer habitat, would represent a substantial loss of habitat diversity and valuable food, cover, and nesting sites. Pre- and post-mining vegetation types are discussed in more detail in Section 3.7, Vegetation. The following sections discuss mining impacts to wildlife groups in the various mine areas.

3.8.1 Big Game

During mining, mine areas may be less suitable for big game. Because mining and reclamation go on simultaneously, however, only part of the area will be disturbed at any given time. Of greater significance is the change in post-mining habitat types. The mine reclamation plan calls for more than a doubling of grassland acreage at the expense of shrub and conifer types. In Area D, shrub and conifer habitat would be reduced by more than two-thirds.

Ponderosa pine and shrub habitats are important to mule deer. It is unknown how successful efforts to reestablish these habitats will be. Further, Western Energy proposes to reduce the amount of ponderosa pine type. Suitability of the area for mule deer use is thus expected to be decreased. The increased rolling grassland habitat after mining may be favorable for pronghorn during spring, summer and fall; however, reduction of sagebrush-grassland may make the area less suitable in winter.

Other impacts due to increases in hunting, road kills, and other human effects could occur with mine development.

3.8.2 Other Mammals

Although mining temporarily eliminates small mammal populations, no especially sensitive species of small mammals would be affected by the planned mining operations. To a certain extent, the small mammal population is important as a source of prey. The amount of prey would be reduced after mining until a diverse, stable vegetative community, adequate to support the kinds and numbers of small mammals present now, is reestablished. Limited studies in various Colstrip area habitats, including reclamation sites, suggest that post-mine small mammal populations may be larger, though less diverse, at least in the early years of reclamation. However, the alteration of the proportions of various habitats could affect the attractiveness of the area to the different small mammal species. This is particularly true of such species as porcupines and chipmunks, which are associated with wooded and shrubby habitats, and with cottontails and marmots, associated with rocky microhabitats.

3.8.3 Mammalian Predators

Mining temporarily renders disturbed areas unsuitable for mammalian predators because of the lack of prey and the proximity to human activity. It is not certain how successful the plans for revegetation will be in sup-

porting prey similar in numbers and diversity to that now on the site. Therefore, it is not known which predators will return to the area nor in what density they may eventually reestablish.

The coyote is the most common mammalian predator in the area, but since the coyote doesn't appear to be habitat- or food-limited in the area, the habitat loss from mine development should not significantly affect local coyote populations directly. However, to the extent that preferred coyote prey species do not recover to populations similar to existing conditions, the mined areas could have a long-term reduction in potential for coyotes.

3.8.4 Upland Game Birds

Five sharp-tailed grouse dancing grounds would be disturbed by mining, four in Area C and one in Area A. Feeding and nesting habitat near these grounds would also be substantially reduced. It is uncertain what effect these impacts would have. Western Energy has committed to attempting to replace dancing grounds and nesting and feeding habitat disturbed during mining.

Most other upland game birds, such as ring-necked pheasant, Hungarian partridge, and sage grouse are infrequent in the mine areas and are, thus, not likely to be significantly affected by the mine. Area D disturbance, particularly the substantial long-term reduction in conifer-shrubland habitat, would probably adversely affect the small Merriam's turkey population.

3.8.5 Waterfowl

Waterfowl nesting and feeding habitat would be reduced during mining. Reclaimed areas should replace this loss, since mallards have been found nesting in adjacent reclamation plots. Mining would not be expected to have appreciable impact on waterfowl species, since the major concentration for waterfowl in the area, Castle Rock Reservoir, would be undisturbed.

3.8.6 Songbirds

The revegetation program would substantially alter the proportions of songbird habitats in the disturbed area. A reduction of shrub and woodland bird species, especially in Area D, would be expected with a corresponding increase in grassland songbirds. The impact to cavity-nesters in ponderosa pine areas would be long term.

3.8.7 Raptors

One golden eagle nest, active in 1978, has been documented in Area C. Golden eagles are regularly sighted, especially in spring, often in and near Area C (ECON, 1975, 1976, 1977, 1978, 1979; Western Energy, 1980). Eagles are protected by the Bald Eagle Protection Act of 1940, as amended

in 1962 (16 USC 668a), which prohibits "taking" of eagles or their nests, active or inactive. The mining plan for Area C calls for disturbance of the eagle nest site in the early 1990's. Alternative nest sites are available in the study area, although their acceptability is unknown. No specific studies have been conducted on hunting territories or food habitats of the golden eagles in the Colstrip area.

The prairie falcon nest located on the same rock outcrop in Area C as the golden eagle nest will also be disturbed. Although the prairie falcon is a species of high Federal interest (Spear 1980), and a species of special concern in Montana (Flath, 1981), it does not have the same degree of legal protection as the golden eagle.

The sensitivity of raptors to disturbance varies tremendously between species and among individual pairs of the same species. Golden eagles and prairie falcons are both considered sensitive to human disturbance (Call, 1978). Raptor nests peripheral to the mining areas include a great-horned owl nest and a prairie falcon nest at Eagle Rock, north of Area D. Both nest sites are one-quarter of a mile or more away from the mining disturbance area and both face the mining operations. Nest abandonment from disturbance due to mining activity is possible.

Mining would destroy nesting and hunting habitat for other raptors, including a localized long-term reduction in mature ponderosa pine habitat and a permanent loss of rock outcrop. Several of the raptors observed in the study area are of both State and Federal concern (Flath, 1981; Spear, 1980). Present evidence is not adequate to assure that revegetation would produce a raptor prey base comparable to present conditions. The area disturbed by mining would be substantial; nearly 20 percent of the study area will have been disturbed by mining by the year 2017. It is also not known to what extent a displacement of hunting territories out of the mined area could affect raptor populations.

3.8.8 Reptiles and Amphibians

Few reptiles and amphibians would be affected by mining. Hognose snakes, of special concern in Montana (Flath, 1981), may be present, but this is not certain, as no special reptile surveys have been conducted. Rattlesnakes and other predatory reptiles would return to the area as reclamation progresses and prey populations recover. Microhabitat changes, particularly reduced rock habitat and winter denning areas, may inhibit repopulation of the area by reptiles. There may also be fewer wet habitats available for species, such as frogs and toads, because of the disruption of East Fork Armells Creek. During mining and reclamation, sediment ponds could provide habitat for reptiles and amphibians.

3.8.9 Fish

Since the fishery resource in the proposed mining area is limited, no significant impacts are anticipated. Regional impacts on fisheries as a recreational resource are discussed in Section 3.12.

3.8.10 Threatened and Endangered Species

The bald eagle and peregrine falcon are the only threatened or endangered species that have been observed in the study area. Neither species frequents the area, and there is no record of local nesting for either species. Inspections of the only prairie dog colony in the study area did not reveal any black-footed ferret sign; because of the colony's size and separation from other colonies, black-footed ferret presence is unlikely. In any case, the colony is north of (outside) Area A and would not be affected by mining.

3.8.11 Mitigations

Where impacts to wildlife habitats are unavoidable, the following mitigations are suggested:

1. Where possible, identify and preserve critical shrubland and coniferous habitats. Future reclamation plans could emphasize reestablishment of shrubs and conifers. Reclamation plans for Area C, now undisturbed and covered by 40 percent shrubland and coniferous habitats, could include more shrub and conifer plantings. Mule deer, pronghorn, chipmunks, porcupines, turkeys, sharp-tailed grouse, and some songbirds depend on shrublands and coniferous areas for food and cover.

2. Establish new sharp-tailed grouse dancing grounds. New dancing grounds could be developed as substitutes for those lost during mining. Locating new dancing grounds at least 2 miles from future disturbances would prevent loss of associated feeding and nesting cover.

3. Blast or excavate sites for raptor nesting in undisturbed rock outcrops. This may compensate for golden eagle and prairie falcon nests in Area C scheduled for disturbance.

4. Increase cover for small mammals and reptiles by locating rockpiles and/or brushpiles on reclaimed sites. Suitable cover may increase small mammal populations. Predators would then benefit from a greater prey base.

5. Add nest boxes to partially compensate for natural tree cavities lost in disturbed coniferous habitats.

6. Tree snags could be identified and protected to supply songbirds and raptors with nesting habitat and perches.

7. Post signs and reduce speed limits to reduce wildlife roadkills.

8. Big game herds could be carefully monitored to determine effects of increased hunting pressure. Strictly enforce conservation laws to reduce illegal killing of wildlife.

3.9 SOCIOLOGY AND ECONOMICS

3.9.1 Economic/Demographic Impacts

3.9.1.1 Economic Conditions

3.9.1.1.1 Employment and Population

Annual employment projections for Rosebud County for the cumulative scenario are presented in Appendix E, Table 48. Employment figures for Rosebud County were derived from Tables 49 and 50 (Appendix E), which show total operations and construction employment for all mines and railroads in the cumulative scenario. The scenario includes the Montco Mine; mines 2, 3, 4, and 5; the Tongue River Railroad, and the Otter Creek Spur.

Total construction employment for each mine was assumed to be the same: 25 employees in the first year of construction, 450 in the second year, and 350 in the third (Intrasearch, Inc., 1981). The following assumptions were made to allocate construction employees to Rosebud County: the number of Montco Mine employees who reside in the county varies according to timing--32 percent of the total is local the first year and 39 percent is local for the second and third year (Mountain West Research, 1981). The percentage is greater for the last 2 years of the project as workers employed at generating Units 3 and 4 become available for mine construction. Of the remaining construction work forces, 65 percent consists of nonlocal employees who reside in Rosebud County during the construction. The percentage of local construction workers for mine number 4 also varies according to timing: 32 percent in year one and 25 percent in years two and three (Mountain West Research, 1981). Of the remaining work force, 65 percent each year are nonlocal residents of Rosebud County.

Mines 2, 3, and 5 are located in Powder River County. Local employment as a percentage of the construction employment at mine number 2 also varies according to timing: 32 percent is local to Powder River County the first year of construction, and 25 percent is local during the second and third years (Mountain West Research, 1981). Of the remaining construction work force, all of which is nonlocal to Powder River County, 80 percent is assumed to be permanent residents of Rosebud County, and 13 percent are non-permanent workers who reside in Rosebud County. The local Powder River County employment assumptions for mines 3 and 5 are 32 percent the first year and 39 percent for years two and three (Mountain West Reseach, 1981). Of the remaining work force, 80 percent are assumed to be permanent residents of Rosebud County and 13 percent nonpermanent residents of Rosebud County.

To estimate the Rosebud County local/nonlocal composition of the Tongue River Railroad construction work force, it was assumed that approximately 40 percent of the total manpower for the 3-year construction period would be supplied locally in Powder River County (Mountain West, 1981). Of the remaining work force, 80 percent is expectd to be from Rosebud County. The nonpermanent Rosebud County work force is estimated to be 16 for the first, 48 for the second, and 22 for the third years of the construction period (Ernst and Whinney, 1981). The local/nonlocal composition of the

construction work force for the Otter Creek Spur was derived in a manner similar to the Tongue River Railroad. Powder River County is expected to supply 63 percent of the work force locally, and 80 percent of the Powder River nonlocal manpower is provided by Rosebud County. In addition to those supplied locally, one nonpermanent Rosebud County resident is expected each year for the 3-year construction period on the Otter Creek Spur.

The local/nonlocal composition of the permanent operations work force, in Rosebud County, of the Montco Mine is assumed to be 85:15 local to nonlocal; mines 2 and 3, and 5 are assumed to be 80:20 local to nonlocal; and mine 4 is assumed to be 90:10 local to nonlocal. No local (Rosebud County) employment is anticipated for the operation of the Tongue River Railroad or the Otter Creek Spur. Railroad operations employees will be based primarily in Miles City.

Construction of the Montco Mine and Tongue River Railroad are projected to begin in 1984. Project employment in Rosebud County will consist of 66 construction workers and 17 permanent mine workers. Peak construction employment for both the mine and railroad will occur the following year, with 492 construction workers and 34 permanent mine workers. In 1986, the last construction year and first production year, project employment will include 342 construction workers and 111 permanent mine workers.

Coal production peaks in 1993 at 12 million tons per year (mmtpy) and continues at this level until 2004. Operations employment at the mine will peak in the year 2003 at 476 permanent workers. Coal production ceases in 2006 and mine closure is expected in 2007 with local employment at 60 workers.

Construction of Mine 2 and the Otter Creek Spur is scheduled to occur between 1993 and 1995. Construction for both projects peaks in 1994 with 323 construction employees residing in Rosebud County. Coal production begins in 1994, and full production (10 mmtpy) is expected to occur between 2003 and 2010. Operations employment will peak between 2006 and 2010 at 368 workers.

The greatest construction activity occurs with the construction of mine 3, beginning in 1997, and mine 4, beginning in 1998. Peak construction employment occurs in 1999, the last construction year for mine 3. Full production of mine 3 (10 mmtpy) occurs from 2006 to 2010, with peak local employment of 368 workers occuring in 2009. Full production at mine 4 occurs in 2007 (9 mmtpy), with employment peaking in 2010 at 378. Construction of mine 5 would begin in 2003. Full production (8 mmtpy) and peak mining employment (256 workers) occur in 2010.

The employment impacts for the cumulative scenario are shown in Table 51 (Appendix E). The potential projects are expected to create 2,694 jobs by 2010 in Rosebud County. Between 1984 and 2004, permanent mining employment increases from 17 workers to 1,224 workers. With the closure of the Montco Mine, mining employment fluctuates slightly between the years 2004 and 2008, then peaks at 1,370 workers in 2010. Nonbasic employment

created by the projects follows a similar pattern. It increases steadily until 2004, fluctuates betweeen 2004 and 2008, and peaks at 0.5 percent of baseline employment in 1984 to a high of 41 percent in 2010.

The numerical contribution to the total employment of Rosebud County by the Rosebud Mine would remain nearly constant over the forecast period. As growth occurs from additional mining projects, the contribution of the mine would decline steadily from a high of about 14 percent in 1985 to a low of about 10 percent in 2010.

The impacts of permanent and temporary heavy construction employment were treated separately in this analysis. Temporary heavy construction employment (both local and nonlocal noncommuters) related to the construction of the Montco Mine and mines 2, 3, 4, and 5 was assumed to have no effect on derivative employment. Retail and service employers in the area were assumed to regard mining employment as long term and would expand or build new facilities to accommodate the enlarged economic base.

The projected employment impact resulting from the projects may have significant implications for Rosebud County. The cumulative scenario employment, when compared to the projected baseline employment, is expected to increase total employment in the county by 9 percent to 40 percent after the first year of construction on the Montco Mine (see Table 51 Appendix E). The largest increases in employment are expected to begin in the mid-1990's, when the Montco Mine is at peak production and when construction and operation of the other mines and the railroads begin.

Population projections for Rosebud County, Colstrip and Forsyth are shown in Table 52, Appendix E. It is assumed that 70 percent of the population increase in Rosebud County from the proposed projects occurs in Colstrip. Thirty-one percent of the remaining population increase is expected to occur in Forsyth, while the balance will be distributed through the rest of the county, with a concentration in the southern part. Small percentages of the population increase due to Tongue River Railroad construction (1984-86) will be allocated to Colstrip and Forsyth. Of the total population increase during these years, 35 workers are expected to live in line camps in 1984, 104 in 1985, and 48 in 1986 (Mountain West Research, 1981). These workers were not included in the community allocations.

The percentage of Colstrip's population resulting from the Rosebud Mine is expected to increase constantly to a high of 27 percent in 1990. The percentage would slowly decrease after 1990 to only 15 to 16 percent in 2010.

Cumulative scenario population projections for Rosebud County parallel those for employment. Population changes associated with the projects fluctuate around an upward trend, depending primarily on the construction cycles and peak mining operations. The population in Rosebud County increases by about 61 percent between 1980 and 2010, from 11,370 persons to 18,271 persons. Between 2000 and 2010, total county population will be between 33 and 41 percent higher than baseline forecasts. The percentage of Rosebud County's population attributable to the Rosebud Mine is expected

to increase to a high of about 14 percent in 1990. After 1990 the percentage would decrease to about 10 in 2010.

The impact on Colstrip will be much more dramatic. The expected baseline population of Colstrip is expcted to stabilize at about 3,700 residents in 1985 or 1986, with the completion of construction of generating Units 3 and 4. However, by 1995, Colstrip's population will total 5,419 persons under the cumulative scenario, or about 47 percent more than the baseline population. The population continues to rise until 2010, when Colstrip's population will total 7,571 persons, a 96.5 percent increase over baseline projections. The population will be 132 percent larger than 1980 but only slightly greater than the 1983 annual peak of 7,259 persons.

Forsyth's population will grow steadily, but without the large surges which occur in Colstrip during the several construction periods. By 2010, Forsyth's baseline population peaks at 2,823 persons and impact population at 494 persons.

3.9.1.1.2 Personal Income

Table 53 (Appendix E) presents mining and construction earnings in Rosebud County due to the cumulative scenario, and Montana personal income taxes paid from Rosebud County residents. Similar data showing projected mining and construction earnings for all employees under the cumulative scenario (within and outside Rosebud County), and Montana personal income tax payments, is shown in Table 54 (Appendix E). Total cumulative scenario personal income and per capita income in Rosebud County through 2010 is exhibited in Table 55 (Appendix E). Personal income (including nonbasic income, rents/dividends/interests, and transfer payments) from the proposed projects fluctuates around an upward trend line over the forecast period. The fluctuations are due primarily to the construction projects which occur during the period. Per capita income of the impact population is significantly higher than the per capita income found in the baseline because of the higher wages and the expected greater rate of growth in income per worker for coal mining and construction (Bureau of Economic Analysis, 1981). The cumulative scenario is forecast to increase per capita income (1980 dollars) in Rosebud County over the baseline projections by 5.5 percent in 1985 and 21 percent in 2010. Between 1990 and 2000, increases in per capita income range from 2.6 percent to 14 percent.

3.9.1.1.3 Northern Cheyenne Reservation

Two Northern Cheyenne now work at the Rosebud Mine. That number is expected to increase to at least 15 within a year and may continue to increase in subsequent years. The expected number of employees constitutes an employment rate that is insufficient to significantly affect the level of wages or unemployment on the reservation.

3.9.2 Social Life Impacts

Rural and agrarian lifestyles may differ from urban and industrial lifestyles in a number of respects. Rural residents often are well rooted in their communities and have long-standing ties to families, friends, neighbors, and places. Community life is highly valued and, for many, makes up a portion of the individual's identity. The pace of life is apt to be slow and relaxed, although making a living may be difficult. Permanence also is valued and, with permanence, a sense of self-reliance, reliability, commitment to the community and commitment to established ways of doing and perceiving things. Conservatism and frugality are common (Gold, 1974a; Ertec, 1982; Beak, 1982). In contrast, urban lifestyles often are much more fast paced, mobile, and anonymous. There are often fewer ties to place, to people and to community. Identity depends more on occupation and nuclear family than in rural areas. Change is a much more common element of urban life than of rural life, and urban people often expect services from government and communities that rural areas cannot provide.

Social and community life in most of Rosebud County remains rural and agrarian in nature, despite the presence of relatively large scale industrial development in Colstrip. To date, most industrial development and its effects in Rosebud County have been specific to the Colstrip area. County informants have stated that energy industrialization has not made its presence felt to any great degree beyond the Colstrip area. Further, the residents of Colstrip perceive themselves and Colstrip as distinctly different from the rest of Rosebud County, an opinion apparently shared by other Rosebud County residents.

Proposed development of additional coal strip mines in Rosebud County will occasion additional urbanization of the county and substantial population growth in Rosebud County, Forsyth, and Colstrip. The impact population associated with additional energy development is expected to comprise from 10 to over 30 percent of the county population between the years 1993 to 2010, 10 to 15 percent of the Forsyth population between 1998 and 2010, and 10 to 49 percent of Colstrip's population between 1983 and 2010. Population growth of this magnitude will be noticeable to affected residents. Further, it is likely that many newcomers to the county will hold values and possess lifestyles different from those of rural Rosebud County residents.

Rapid growth in Colstrip during the early and mid-1970's initially resulted in conflict between newcomers and the existing residents of the area and, reportedly, a destruction of the sense of community held by area residents. Prior residents reported not only a loss of community, but also feelings of insecurity and anomie. In addition, many newcomers to the area reportedly felt bored and isolated, particularly the unemployed wives of Colstrip workers. These conditions resulted in high rates of alcoholism (high resident participation rates in alcoholism programs), family distress, and high rates of crimes of violence (Gold, 1974a). Current residents of Colstrip report that social life continues to be unstable for many, with relatively few of the social amenities urban people usually expect. A large proportion of Colstrip residents are considered (and con-

sider themselves) to be transient, and feelings of powerlessness, rootlessness, and anonymity reportedly are widespread. The persistence of these phenomena in Colstrip is attributed to population fluctuations and the presence of a large proportion (about 30 percent) of transients who cannot or will not make a commitment to the community. Continued population growth and fluctuations may result in similar conditions.

The projected increase in population for the remainder of the century is not as large as that experienced by Colstrip in the 1970's. Nonetheless, some conflict may be expected to arise between immigrants and rural residents who have not had the experience of adjusting to a rapid influx of newcomers. The sudden presence of relatively large numbers of people has proved stressful to rural residents (Gold, 1974a, 1974b, 1975a). Further, the modes of social interaction, expectations regarding personal behavior, and the values of the two groups may differ substantially, and engender misunderstanding and resentment when the groups collide. In Colstrip, the values of newcomers and previous residents differed with regard to community, education, property rights, neighboring, work, and personal lifestyle (Gold, 1974a, 1974b). Some of these differences persist today, according to area residents. These effects will be attenuated to the degree that the immigrants are from or are accustomed to rural areas. These conflicts may be mitigated by the previous experience of rural residents with industrialization during the 1970's.

The Northern Cheyenne that would be most affected by the Rosebud Mine are mine employees and their families. The majority of employed Northern Cheyenne now work for the government (Northern Cheyenne Planning Office (NCPO), August 1981). The Rosebud Mine's expected increase in Northern Cheyenne employment would begin expanding the importance of mining to the Northern Cheyenne economy. The expansion may begin to strengthen the tie between the Northern Cheyenne and private business and facilitate the Northern Cheyenne's assimilation into the mainstream of American society (BLM, 1980, p. 145).

Assimilation, however, may be unwanted. Even if they became absorbed into non-Indian society, the costs to the Indian people might be great (BLM, 1980). Cultural change may mean an increasingly stressful life (BLM, 1980).

The Northern Cheyenne have a number of concerns over mine development. First, they worry about increased conflict both among themselves and with non-Indians. Such conflict could arise from the changing values and lifestyles of those employed at the mine, who would have daily contact with non-Indian society. These mine employees would make more money than most other Northern Cheyenne and, thus, be able to buy more goods and services. They may also gain influence in tribal politics and, therefore, influence the Northern Cheyenne's tribal position on coal development within the reservation.

The money earned at the mine by the Northern Cheyenne would bring a minor increase in reliance on a cash economy and increased exposure to other values. This could indirectly decrease the incidence of communal living, resulting in the conveyance of Cheyenne customs and language

becoming more difficult. The practice of families and their relatives living together nurtures the transfer of traditions and Cheyenne knowledge. In particular, the Northern Cheyenne are concerned that abrupt changes brought by increased participation in mining without mitigating measures could destroy the sense of family and community cohesion that has maintained and characterized the traditional Cheyenne (NCPO, August 1981). In addition, subsistence activities (hunting, gathering, etc.) may decrease with the increased use of cash.

Northern Cheyenne are concerned that increased cross-cultural contact will lead to conflict. Increased contact could also result in more intermarriage, which might hasten the eventual loss of the Northern Cheyenne as a people (NCPO, December 1981).

Another concern of the Northern Cheyenne is that the influx of non-Indians would intensify competition in social activities and cause social frustration. More interaction with non-Indians may promote family problems. The Northern Cheyenne feel coal development would also exacerbate alcoholism and other chemical abuse (NCPO, December 1981). Alcoholism and drug abuse are now overwhelmingly considered by the Northern Cheyenne as the most serious social problems on the reservation.

The need for mitigating conflict between immigrants and existing residents will be the greatest in southern Rosebud County. The single most important step necessary to reduce the possibility of conflict is full disclosure of development plans and early communication between area residents, county officials, and permit applicants. This will allow for a cooperative relationship and the planning critical to a smooth transition from a rural and agrarian lifestyle to a semi-industrial local society. In addition, employers can institute programs sensitizing incoming employees to these social issues.

3.9.3 Social and Community Services Impacts

3.9.3.1 Law Enforcement

The nineteen existing deputies will adequately serve projected baseline poulations of 12,000 to 13,000. Based on this ratio, the projected population due to the potential projects will require an additional 3 deputies by 1995, 3 more by 2000, and a total of 28 by the year 2010. Population projections for the Colstrip area indicate that at least two of the three additional deputies should be located there, and in the southern areas of Rosbud County. The close to doubling of population in the Colstrip and southern areas of the county will necessitate either additional space in the office/detention facility in Colstrip, or a new holding facility in the Ashland/Birney area.

To mitigate law enforcement impacts, three additional deputies should be hired by 1995, three more by 2000, and three more by 2010. At least two-thirds of the additional staff should be located in Colstrip and southern Rosebud County. Either additional space should be made available in the office/detention facility in Colstrip, or a new holding facility should be constructed in the Ashland/Birney area.

3.9.3.2 Fire Protection

The volunteer force and equipment in Forsyth are considered adequate to service projected impact population levels, based on existing household-based service standards (Mountain West Research, 1981). These standards indicate that an additional 6 volunteers may be required in Colstrip by the year 2000, and a total of 25 by the year 2010. Existing equipment should be adequate to serve projected populations.

To mitigate fire protection impacts, the Colstrip volunteer fire department may have to add six volunteers by the year 2000, and another three by the year 2010.

3.9.3.3 Sanitary Sewer

The additional Forsyth population attributable to the potential projects will not have a significant impact on the local sanitary sewer systems. Similarly, the additional Colstrip population attributable to the potential projects will not significantly affect the Colstrip sanitary sewer system.

3.9.3.4 Water Supply

The Forsyth water supply and treatment facilities are adequate to service projected population levels. If the additional population forecast for Forsyth resides in the newly developed areas east and southeast of town, a booster system will probably have to be installed to facilitate water supplies in this area. Population-based standards for water storage indicate that existing storage capacity will serve about 2,600 residents, the current population. The potential projects will cause Forsyth population to exceed this amount by about 400 residents in 2000, or 15 percent. Standards indicate that an additional 200,000 gallons of capacity will be required by 2000, with another 60,000 by 2010, due to the forecasted population increase in Forsyth.

This need for additional storage capacity contradicts the 1972 engineering study for the city of Forsyth, which rated the storage capacity of the system currently in place to be adequate to serve approximately 3,500 residents, an excess of 5.5 percent of the projected cumulative scenario population (Wetstein, 1982).

The forecast population levels in Colstrip will not significantly affect the local water supply system. Water storage requirements of the forecast population levels in 2004 will exceed existing capacity, according to population-based standards (Mountain West Research, 1981). An additional 220,000 gallons of capacity will be required by 2010. However, this additional capacity will not require new storage facilities. The current system design is rated to serve 8,000 residents, 5.7 percent more than the cumulative scenario projections. The additional 220,000 gallons are available in the system's clear-well storage, which contains up to 380,000 gallons, of which 250,000 gallons is usable in the system (Connell, 1982).

To mitigate water supply impacts, Forsyth may have to expand its water storage capacity 260,000 gallons by 2010, according to population-based standards.

3.9.3.5 Solid Waste

The additional population due to the potential projects will result in the landfill needing additional capacity 2 to 4 years earlier than it would have under the baseline case. The collection system in Forsyth is adequate to serve projected populations. Projected population increases in Colstrip and southern Rosebud County will require three additional collection trucks, based upon the existing ratio of trucks to population.

To mitigate solid waste system impacts, three additional collection trucks will have to be added to the collection system in Colstrip and southern Rosebud County.

3.9.3.6 Social Welfare

Population-based standards indicate that one additional social worker and one additional paraprofessional will have to be added to the Department of Public Welfare by the year 2005 (Mountain West Research, 1981). This additional staff should be located in the Colstrip outreach office because of its proximity to the area of greatest population growth. Expenditures for staff under the recent Coal Board grant will fill this need, if continued. The programs supported by the grant are intended to attack those social programs most often mentioned by service providers and residents in the impact area.

3.9.3.7 Medical Services

The number of physicians in Rosebud County is inadequate to serve existing population levels. According to population-based medical service standards the county should have an additional five to seven physicians today (Mountain West Research, 1981). Forecast population levels attributable to the potential projects imply that two more physicians will be needed by 1995, and another two by 2005, in addition to the five to seven currently needed. At least two of the four additional physicians should be located in the central to southern parts of the county.

The low occupancy rate at the Rosebud Community Hospital implies that additional hospital beds will not be needed. About 21 beds are currently unoccupied. Additional beds will be needed only if long-standing patterns of county residents seeking hospital service elsewhere are modified.

Based on the existing ratio of one psychologist staffing each of the mental service offices in Forsyth and Colstrip, at least one additional psychologist should be added to the staff to service projected population levels.

Population-based service standards indicate that the existing six ambulances in the county should be sufficient to service the projected

population (Mountain West Research, 1981). However, projected growth in southern Rosebud County and its distance from medical services may require that an independent ambulance system be developed. Service standards also suggest that three to five additional EMT's be available after the year 2000 in Colstrip, and that by 2000 an additional public health nurse should be hired (Mountain West Research, 1981).

To mitigate medical services impacts, local officials should investigate programs capable of augmenting the professional medical staff in Rosebud County. The area should be served by eight additional physicians by 1995 and another two by 2005. One-half of these new physicians should move to Colstrip and southern Rosebud County. One additional psychologist should be added to the mental health program. After the year 2000, an additional public health nurse should be hired, and three to five additional EMT's may be needed in Colstrip.

3.9.3.8 General Government

The additional Rosebud County population resulting from the potential projects may require an additional five to seven personnel in the county offices, according to population-based standards (Mountain West Research, 1981). The increased staff would not be necessary until 1992-94, and would then increase along with population. These standards imply that the city of Forsyth administrative office will require two additional personnel by the year 2000.

The existing ratio of county shop personnel to county population indicates that forecast population increases will require the addition of 13 shop-related personnel and 9,000 square feet of shop space. Forecast population increases are not expected to significantly affect the city of Forsyth shop.

To mitigate impacts on general government, according to population-based standards, the Rosebud County offices should hire up to seven additional personnel by 2010. Forsyth city offices will also need two additional personnel by 2000. Thirteen additional shop personnel should be hired by Rosebud County, and 9,000 square feet of shop space should be added.

3.9.3.9 Library

Existing excess space and the interlibrary loan capability will lessen the need for additional volumes and space. Assuming that existing services will absorb one-half of the additional population-based demand, population-based service standards indicate that one additional staff person may be required by the year 2000, and that an additional 2000 square feet of space and 4,000 volumes will be needed by the same year (Mountain West Research, 1981).

To mitigate impacts on the library, by the year 2000 an additional person should be added to the library staff, and 2,000 square feet of space and 4,000 volumes should also be added.

3.9.3.10 Housing

Table 56 (Appendix E) contains projections of housing demand in Rosebud County, Colstrip, and Forsyth as a result of the potential projects. The years for which projections are shown are generally years of peak construction, with the exception of 1990 and 2010. In 1985, the potential projects are forecast to increase housing demand 10 percent in the county, 22 percent in Colstrip, and 4 percent in Forsyth. By 1999 the number of households are projected to increase 34 percent (1,558) in the county, 21 percent (1,004) in Colstrip and 14 percent (166) in Forsyth. By 2010 households in Colstrip are forecast to increase by 98 percent, or 1,305 additional households, Rosebud County by 41 percent, or 2,051 new households, and Forsyth by 17 percent, or 223 new households.

The level and phasing of potential development will determine actual future housing needs and the need for mitigation measures. Full disclosure of development plans and early communication between permit applicants, county officials, and those involved in the housing industry will enable future household needs to be met in an orderly and planned fashion.

The Sunlight Development Company should continue to carefully monitor future coal development plans in Rosebud County, as they may affect the demand for Colstrip housing. Permit applicants should consider a joint venture with Sunlight Development Company, wherein the latter would provide housing in Colstrip for some or most of the increased population resulting from the proposed projects. The permit applicants could guarantee rentals and/or home purchases, and thereby back the financing necessary for the new construction. This approach should also be considered for joint ventures with other developers to provide housing in southern Rosebud County.

3.9.3.11 Education

Table 56a, Appendix E, contains school enrollment projections for Colstrip School District #19 and Forsyth School District #4. The years for which projections are shown are generally years of peak construction, with the exception of 1990 and 2010. The impact of the cumulative scenario is projected to increase Colstrip elementary school (K-8) enrollment by 13.3 percent, or 116 students, in 1985; 31.3 percent, or 270 students, in 1995; and roughly 50 percent, or 444 students, in 2000. Projected school enrollment impacts will be slightly smaller in the Colstrip High School. High school enrollment is expected to increase by 38 students in 1985 (10.2 percent), 87 students in 1995 (23.5 percent), and 143 students in 2000 (38.0 percent).

Currently, there are 60 classrooms in Colstrip serving students in grades K-8. The old high school contains 31 classrooms, which is expected to be available for grades 7-8 after the new high school is completed (Clave, 1982). The new high school will contain 27 classrooms. Using maximum class-size accreditation standards, there will be classroom space sufficient for approximately 2,600 students in grades K-8 and 810 students in grades 9-12. The projected enrollment in 2010 will be about 58 percent of maximum capacity in grades K-8 and 71 percent of maximum capacity in

grades 9-12. Additional expenditures for instructional personnel will be necessary.

The proposed projects are expected to increase enrollment in the Forsyth elementary district by 2.7 percent, or 15 students, in 1985; 10.6 percent, or 59 students, in 2000; and 13.0 percnt, or 77 students, in 2010. The projected increases in the Forsyth high school district are 8.0 percent, or 21 students, in 1985; 19.7 percent, or 51 students, in 2000; and 24.5 percent, or 67 students, in 2010. These school enrollments would take up 82 percent of maximum classroom in the elementary district and 57 percent of maximum classroom capacity utilized in the high school. Additional expenditures for instructional personnel will be necessary.

To mitigate education impacts, the Colstrip School District will have to hire between 12 and 40 new professional staff by the year 2000, depending on whether existing student/teacher ratios will be maintained or a higher ratio will be acceptable. The Forsyth School District should hire six additional professional staff by 2000 to maintain existing student/teacher ratios.

3.9.3.12 Northern Cheyenne Reservation

Non-Indians moving into the area are not expected to live on the reservation. But the population on the reservation is expected to increase approximately 31 percent from natural growth over the life of the Rosebud project. Only the strain on community services related to the Rosebud Mine will be considered here.

Many community services, such as housing, water supply, and community waste disposal systems are not expected to be affected by the Rosebud Mine, since no mine-induced population increase is projected for the reservation. Only those services tied to increased commuter or recreational traffic, such as law enforcement and perhaps some health services and social services, are likely to be affected.

Additional law enforcement requirements are likely to strain an already inadequately staffed tribal police force. Increased enforcement demands are most likely to involve traffic violations, motor vehicle accidents, and recreational resources.

Health service impacts are not easily forecasted. Some increase in motor vehicle accident rates would place a slight additional burden on the clinic and ambulance service. These services appear to be adequate to absorb additional clients, but the unknown mix of Indian/non-Indian new clients complicates the prediction of future demands.

Social welfare and mental health services may also receive increased demand, but how much demand and the portion attributable to Rosebud Mine development cannot be determined. Projection of mining-related demand would require the assumption that additional stress (social and psychological) would be placed on the Northern Cheyenne. Another necessary assumption would be that the increased stress would lead to some proportion

of increased service utilization to remove either the stress or stress-induced social and personal problems. At this point, very little is known about how much stress is created by increased Native American participation in mining. Without the ability to predict the amount of stress being generated by mining activity, there is no basis for predicting increased demand for social welfare or mental health services.

3.9.4 Public Finance Impacts

The potential projects would add significantly to the taxable value of the county and both Colstrip school districts. The projects are expected to lessen the decline in taxable value in Forsyth as more people settle there.

The forecasted impacts of the potential projects on the fiscal condition of Rosebud County are presented in Table 57 (Appendix E). It should be noted that property taxes on nonproject property are expected to decrease as the total taxable value of the county is increased by the coal production and equipment associated with the various projects. The net effect on taxable value in the county due to the two primary taxable components of the mine expansion, capital investment and gross proceeds, is shown in Table 58 (Appendix E). Under the cumulative scenario, total taxable value peaks in 1990. However, Table 59 (Appendix E) indicates that the projects constitute an increasingly greater percentage of county taxable value through 2005, as the baseline taxable value diminishes. The increase in total taxable value under the balanced budget scenario forces mill levies down below those projected under the baseline.

The net effects of the cumulative scenario on Rosebud County local revenues and operating expenditures are shown in Table 60. At most, the cumulative scenario would result in an increase of approximately 42 percent in either operating expenditures or local revenues.

The population influx resulting from the projects is expected to result in the need for several capital improvement projects: a 2,000-square-foot addition to the county library in the year 2000 at a cost of $70,000 (Sinnott, 1982); a 9,000-square-foot addition to the county shop in the year 2000 at a cost of $225,000 (Sinnott, 1982); a new jail facility in the southern part of the county in 1995 to serve the Colstrip-Ashland area, including 864 square feet for a justice court and office, 1,500 square feet for four jail cells and an impoundment area at a total cost of $190,000 (Ash, McCrae, Sinnott, 1982); and a new ambulance valued at $35,000 to be needed in the year 2000. In this analysis, each of these capital outlays are assumed to be funded through the issuance of bonds. This presents a worst-case example in terms of property taxes. However, in all likelihood, Coal Board grant money will be available to help defray the cost of the outlays.

The projected impact of the potential projects on Forsyth revenues and expenditures is shown in Table 61. Property tax collections are expected to increase by as much as 28 percent over the baseline by 2010, while mill levies are expected to increase by no more than 9 percent. This is due to the lessening of the decline in taxable value which was forecast in the baseline scenario (see Table 62 Appendix E).

The forecasted impacts of the cumulative scenario on the Colstrip Elementary School District #19 and High School District #19 are shown in Tables 66-70 (Appendix E) (see Table 58 for impact taxable value on High School District #19). The peak in the increase in operating expenditures for the elementary district is 67 percent and for the high school district 71 percent. (See Tables 67 and 70, Appendix E.) However, because of the addition of the projects to the property tax base, the net increase in the tax burden is considerably lower than the increase in operating expenditures in the elementary district. The net increase peaks at 35 percent in year 2000 and thereafter declines to a 20 percent increase in year 2010. The burden on Colstrip High School District #19 property owners is expected to decrease by as much as 16 percent as a result of the addition to the tax base from the project; however, as the gross proceeds and capital investment taxable valuations decline (see Table 58, Appendix E), the burden on the existing tax base is expected to increase by 26 percent in 2010. (See Table 70, Appendix E.)

Tables 71 through 74 (Appendix E) show the forecasted impacts of the cumulative scenario on both the Forsyth Elementary and High School Districts. While neither of the districts will experience an increase in their tax base directly from the siting of any of the potential projects within their boundaries, the influx of people and subsequent development is expected to add to the tax base. Thus, the net percentage increases in operating expenditures, which peak at 13 percent for the elementary district and 25 percent for the high school district, are paralleled by similar net percentage increases in local property tax revenues. No substantive changes in the mill levies occur.

In addition to creating additional revenues for the local taxing jurisdictions, the potential projects are expected to generate (1) payment of approximately $548 million (1980 dollars) in Federal royalties, roughly half of which would be returned to the State, and (2) payment of approximately $925 million (1980 dollars) in Montana coal severance taxes.

Approximately $287 million (1980 dollars), or 52 percent, of the Federal royalties and $486 million, or 52 percent, of the coal severance taxes would come from mining activity in Rosebud County at the Montco mine and mine 4. Table 75 (Appendix E) lists severance tax and royalty payments for various years of the cumulative scenario.

The projects would also generate $48 million (1980 dollars) in State personal income taxes from direct employment in Rosebud County (see Table 55, Appendix E). Total personal income tax payments from direct employment in Rosebud County and outside Rosebud County as a result of the cumulative scenario are shown in Table 56 (Appendix E). These total tax payments are estimated to total $62 million (1980 dollars) by the year 2010.

The population influx resulting from the cumulative scenario is expected to necessitate an additional water storage tank of 260,000 gallons in Forsyth in the year 2000 at a cost of $150,000 (Wetstein, 1982). The net effects of the cumulative scenario on operating expenditures and local revenues in Forsyth is shown in Table 63 (Appendix E). At most, the impact of the potential projects will result in a net increase of 17.5 percent in operating expenditures and 19.7 percent in local revenues.

The forecasted impacts of the cumulative scenario on the Colstrip townsite finances are presented in Table 64 (Appendix E). The net effects of the potential projects on local revenues and operating expenditures in the Colstrip townsite, as presented in Table 65 (Appendix E), indicate that the proposed expansion would result in an increase of approximately 96.5 percent in either local revenues or operating expenditures. The influx of workers into the townsite is not expected to significantly detract from the level of services required, because of previous planning by townsite managers.

3.9.5 Slowdown and Cessation of Coal Mining

Recent projections of coal demand indicate that mining in Rosebud County could continue until the end of the twenty-first century. Even so, unforeseen circumstances could slow or stop mining. If mining operations were drastically cut back, the social and economic conditions of Rosebud County, particularly Colstrip, would change dramatically.

An analysis of how a mining slowdown or shutdown would affect Rosebud County is highly speculative, primarily because the date and conditions of such a "bust" are unknown. Nonetheless, some general predictions can be made, based on information gained from mining shutdowns in similar one-industry areas.

The forecast of a mining "bust" contained here relies on a number of assumptions about the future:

- The economy of Montana will continue to rely on agriculture and natural resource extraction.
- No significant population movements, other than those already projected in this document, will occur.
- Electricity generation and production of synthetic fuels in Montana at "mine mouth" facilities will be limited to those already existing.
- Colstrip Generating Units 1 through 4 will operate as long as a local supply of coal lasts.
- Trade patterns of the region will not change; Billings and Miles City will remain as regional trade centers.

Based on these assumptions, the bust period of mining in Rosebud County would not resemble recent shutdowns in communities, such as Butte and Anaconda. Instead, the bust would come slowly. Long-term contracts for coal would take a number of years to run out. Mining most likely would be phased out over a period of 3 to 10 years, giving local government time to plan for and mitigate impacts.

3.9.5.1 Employment and Income

During the years of coal extraction, the population and employment in Rosebud County would probably remain stable near the level projected for 2010 (Tables 51 and 52). As mining is phased out, unemployment would rise and remain high. Closure of the mines and generating units would eventually eliminate 2,700 to 2,800 jobs. These jobs would represent about 30 percent of the total 9,300 jobs in Rosebud County in 2010.

Owing to the expected long life of mine operations, the shutdown would probably take place at a time when most workers would be long-time residents, perhaps third- or fourth-generation descendents of local families. Workers would find that their training is not readily transferable to other industries. Many workers would be older, often near retirement. For all these reasons, workers would be reluctant to move, keeping unemployment high.

Job losses to mining workers would cause job losses in trade, services, and support industries. Some of the losses would be compensated for by severance pay, early retirement, and the creation of new jobs. Still, it is estimated that for every 100 jobs lost in mining, 50 would be eliminated elsewhere. The result would be 1,400 jobs lost in trade, service, and support industries.

Mine closures, in short, would eliminate a total of about 4,200 jobs, or about 45 percent of the Rosebud County work force of 9,300 people. This would cause a population decline of about 8,400 people, roughly 46 percent of the county's population (based on the projections for 2010).

Mine closure would also affect public finance, shifting school district tax burden from mining companies and the power plant to individuals and agricultural operations. The increased burden to individuals would be partly offset by (1) the reduced cost of serving a smaller population, (2) the use of cash accumulated during the "boom" period, and (3) State assistance from coal production taxes. These compensating effects, however, would not stop economic decline.

3.9.5.2 Social Conditions

During the years of coal extraction, the social conditions in Rosebud County would remain stable, similar to the conditions in 2010. In Colstrip, planned community development would prevail. In Ashland, unplanned development, extending along the borders of the Tongue River, would probably prevail. Colstrip would serve as the center of commercial and social services for the coal areas of Rosebud County. The scattered development in the Ashland area would discourage the growth of commercial services.

Agricultural interests would remain important in southern Rosebud County throughout the coal extraction period. The number of operations, however, may decrease, as long-time operations sell out. Agricultural interests may become socially, economically, and politically isolated. In

the northern part of the county, by contrast, agriculture would remain the dominant economic force, and Forsyth would remain a center of social activity for northern county agricultural people.

Good pay and job stability during the coal extraction period will discourage turnover. Low turnover would increase the likelihood that the population would contain a disproportionately high percentage of older age groups and a disproportionately low number of young adults and families with children. Owing to the high wages of miners, the population would be affluent in comparison to the remainder of Rosebud County and Montana.

The residents of Colstrip during the coal extraction years could develop a strong sense of community. They may form numerous social clubs and remain socially isolated from the remainder of the county. In Ashland, by contrast, the sense of community would probably remain weak, owing to the scattered home settlement and the lack of commercial development. Social clubs would be fewer in number and less active than in Colstrip.

Social stratification would probably continue and possibly increase in Colstrip during the years of coal mining. People would associate primarily with others in the same line of work. Relations between blue and white collar workers could become more formal, institutionalized through meetings between labor unions and management.

Residents of Colstrip and Ashland are likely to remain isolated from the rest of the county during the coal extraction period. Relations with others in the county would be mainly for business or political ends. Socially, relations may become antagonistic, as differences over lifestyles and development clash. The lifestyles of residents in the coal development areas may be more materialistic. Jobs may be viewed as a means to security. In agricultural parts of the county, on the other hand, lifestyles would remain much as they are today--slow paced, informal, stressing family and the satisfaction of work.

The shutdown of mining operations would radically change the social conditions of the coal extraction period. As jobs disappear, residents may seek and commute to jobs nearby. The most mobile residents--probably the young, educated, without property--would move. Most residents, however, would be reluctant to move away, owing to ties to the community, a lack of saleable skills, or nearness to retirement. Unemployment may then engender apathy, hopelessness, less stability in social contacts, and a decrease in satisfaction with the quality of life.

The unemployment conditions of the bust may expand the economic lower class. Some workers and their families would accept employment that the family members would have refused during the years of coal extraction. Some families would have to adjust their living standards downward. Colstrip would probably become polarized between the "haves" and "have nots." Social ills, such as drinking, child abuse, and divorce, would probably rise.

Within a decade of the cessation of mining, Colstrip, and to a lesser extent Ashland, would probably become economically depressed retirement

communities. Although agriculture may increase in importance, Colstrip and Ashland would probably become mining ghosttowns.

3.9.6 Mitigations

Social and Community Mitigations.--If only the existing mines in Rosebud County continue to operate, few mitigations are needed and assignment of responsibility for mitigations is relatively simple. Mitigation activities only require coordination between two coal companies, Montana Power Company, Sunlight Development, and government agencies. If, however, other mines are developed (the cumulative scenario), the need for mitigation increases becomes greater, coordination of activities is more important, and assignment of responsibility is more difficult.

Mitigation programs have been developed that assume mining companies and government agencies share responsbility for reducing impacts. One way to determine each party's share would be to create a coordinating organization similar to the Colorado Joint Review process, a group that has operated successfully to reduce and manage impact. This organization would need to address the mine's potential impacts on population distribution and housing. The following are mitigation techniques used in circumstances similar to those in the Colstrip area:

- Providing camps for temporary, especially single, workers.
- Employing local residents when possible.
- Encouraging workers moving into the area to locate where facilities and services already exist by providing information, assistance, or incentives to employees, developers, financial institutions, and local governments.
- Making housing more affordable by helping buyers, sellers, developers, or financing agents. The aid could include development incentives, such as interest rate buy-downs, mortgage underwriting, purchase guarantees, and payments for developing facility and service improvements.

The organization could consider a variety of mitigations to help local governments provide facilities and services. These might include such measures as having the companies help local governments put together 5-year capital improvement programs. Financing of these programs could come from company guarantees of public debt, advance purchase of plant investment fees, direct loans, or assistance in seeking grants or loans from State and Federal agencies.

Other mitigation measures by the company might include financial and material help to local governments. The company, Federal, or State agencies might provide technical assistance programs or training and recruitment assistance for local technicians and professionals. Some programs could supply information about local facilities and services, the economy, and related topics.

Impacts on some facilities and services may require specialized means of mitigation. For instance, negative effects on health care services might be mitigated by monitoring the characteristics of the new labor force and providing the information to local health resource planners. A support recruitment program for health professionals could also be instituted.

Public Finance.--No recommendations.

Employment and Population.--Emphasis should be given to the hiring of local residents in Rosebud River counties. Special effort should be made to hire from the Northern Cheyenne populations.

Personal Income.--No mitigation needed.

3.10 LAND USE

3.10.1 Local Direct Impacts

The major direct impact on land use over the life of mine would be the addition of approximately 16,000 acres of mining disturbance at the Rosebud Mine, although this acreage would be in various stages of reclamation at any one time. This represents an increase of about 585 percent over current disturbance at the Rosebud Mine complex. After reclamation, the land use pattern would reflect a decrease in cropland of about 1,691 acres and a decrease in ponderosa pine forest of about 1,626 acres (See Sections 3.6.5 and 3.7.4). There would be a corresponding increase in shrubland and grassland acreage. (See Table 3.10-1.)

The amount of cropland displaced by the proposed plan represents about 1.3 percent of the total cropland in Rosebud County. Due to the anticipated mixing of clayey and sandy soil types, use of reclaimed areas after mining as cropland may not be feasible.

The increase in mining disturbance would cause a decrease in cattle (AUM) production until the completion of reclamation. The worst-case average acreage that would be out of production at any given time over the life of mine (assuming reclamation of boxcut at the end of mining) is estimated to be approximately 1,364 acres for Area A, 840 acres for Area B, 2,296 acres for Area C, 833 acres for Area D, and 220 acres for Area E. Assuming a pre-mine production level of 0.3 AUMs per acre, the loss of AUMs averages, over the life of mine, about 409 AUMs per year for 25 years in Area A, 252 AUMs per year for 25 years in Area B, 689 AUMs per year for 43 years in Area C, 250 AUMs per year for 33 years in Area D, and 66 AUMs per year for 14 years in Area E.

At the end of mining, AUM production would actually increase. The increase would stem from Western Energy's plans: first, much of the land now in ponderosa pine forest would be reclaimed as grass and shrub grazing land. Second, all disturbed cropland would be reclaimed to grazing land. Third, the old Northern Pacific spoils within the permit areas would be reclaimed, creating more acreage of grazing land. (Some acreage in Area E now occupying old spoils may be converted to industrial use as the facilities near Colstrip expand.)

In areas where the boxcut represents a high percentage of the total disturbance, the average disturbance at any given time over the life of the mine could be considerably reduced if the boxcut were reclaimed at the beginning of mining rather than at the end. This would reduce the average point-in-time disturbance by nearly 40 percent in Area A.

Timber stands in Area D are estimated to be worth about $400 per acre. If they are harvested prior to mining, nearly half a million dollars may be gained. Portable sawmills in Ashland and Lame Deer could be used.

TABLE 3.10-1

SUMMARY OF LAND USE CHANGES

LAND USE CATEGORY	PRESENT USE(acres)	USE DURING ACTIVE MINING(acres)	POST-MINING LAND USE (AFTER RECLAMATION) (acres)
AREA A			
Grass and Shrub Rangeland	2,184	264	3,758[a]
Conifer Rangeland	807	223	405
Cropland	193	68[b]	68
Under Reclamation	811	811	0
Active Disturbance	236	2,865	0
Urban or Industrial	93	93	93
	4,324	4,324	4,324
AREA B			
Grass and Shrub Rangeland	2,812	492	3,235[a]
Conifer Rangeland	107	19	203
Cropland	116	0[b]	0
Under Reclamation	213	213	0
Active Disturbance	190	2,714	0
Urban or Industrial	0	0	0
	3,438	3,438	3,438
AREA C			
Grass and Shrub Rangeland	6,349	464	8,013[a]
Conifer Rangeland	512	30	157
Cropland	1,471	162[b]	162
Under Reclamation	0	0	0
Active Disturbance	0	7,676	0
Urban or Industrial	8,332	8,332	8,332

TABLE 3.10-1 (con't)

SUMMARY OF LAND USE CHANGES

LAND USE CATEGORY	PRESENT USE(acres)	USE DURING ACTIVE MINING(acres)	POST-MINING LAND USE (AFTER RECLAMATION) (acres)
AREA D			
Grass and Shrub Rangeland	1,772	195	3,099[c]
Conifer Rangeland	1,415	280	502
Cropland	176	35[b]	35
Under Reclamation	0	0	0
Active Disturbance	273	3,126	0
Urban or Industrial	0	0	0
	3,636	3,636	3,636
AREA E			
Grass and Shrub Rangeland	568	0	1,842[a]
Conifer Rangeland	52	0	54
Cropland	0	0[b]	0
Under Reclamation	471	471	0
Active Disturbance	805	1,425	0
Urban or Industrial	1,896	1,896	1,896
	3,792	3,792	3,792

[a] This acreage includes areas that are presently undesignated as to which vegetation type they will be reclaimed. It may include some conifer zone revegetation.

[b] This acreage will vary through the mining period as there will always be some disturbance under reclamation. Acreages shown reflect minimum reclamation and are less than what would actually occur.

[c] Some permanent facilities may expand into this area, although that is not certain at this time.

3.10.2 Direct Regional Impacts

In the cumulative senario, all projected coal-related development would disturb about 49,000 acres in Rosebud, Powder River, and Custer Counties (Montana Department of State Lands, 1981, 1982). About 36 percent of the total (see Table 3.10-1) would be due to the Rosebud Mine.

3.10.3 Indirect Impacts

The Colstrip Townsite Expansion Master Plan calls for increased housing facilities, streets, and parks to meet demands of power plant construction (units 3 & 4) and coal mine expansion (Rosebud County Planning Board, 1980). This land use plan is expected to adequately incorporate the population influx resulting from expansion of the Rosebud Mine. The personnel required for the expansion of the mine would be expected to fill vacancies created at the completion of construction of units 3 & 4. Therefore, increased urbanization of Colstrip will not be as dramatic as it might be without the out-migration of construction workers for units 3 & 4.

Continuation of the industrialization trend in Rosebud County would tend to bring more people into the area than those simply required for expansion of the Rosebud Mine. This could cause increased development of rural areas along highways, additional roads, railroads, and power lines, as well as increased residential acreage in Forsyth and Lame Deer. In addition, expansion of the mine would close private land previously available for recreation (such as hunting) to public use until after reclamation.

Because coal development would not result in a population change on the Northern Cheyenne Reservation (see Section 3.9.3.11), there would be no change in land use patterns on the reservation.

3.10.4 Impacts along Conveyor Corridor

The conveyor corridor would cut across the subirrigated alfalfa field located in the railroad loop in Area A. This field is important to the ranching operation of the owner. If the alfalfa production is diminished (as it will be by the elimination of some acreage and possibly by interfering with irrigation) a decrease in livestock production could last until the conveyor is removed. Rerouting the conveyor to circumvent the alfalfa field in Area A would alleviate any impacts the route might cause.

2.10.5 Mitigation

The mining companies should encourage their in-migrating employees to locate in established communities to minimize the conversion of agricultural land to residential use.

3.11 TRANSPORTATION

Projected increases in coal mining in Rosebud County would cause an increase in road and rail use due to increased commuter traffic, population, and coal production.

3.11.1 Road Systems

The largest growth in traffic from the Rosebud Mine, the other mines in the cumulative scenario, and the development of the Tongue River Railroad would occur on the following road segments: FAP 39 between Colstrip and Lame Deer; FAP 37 between Lame Deer and Ashland; FAS 37 between Ashland and Broadus; FAS 566 between Ashland and the proposed Montco Mine; and other secondary roads in the Ashland vicinity. Increased employment at the Rosebud Mine will also slightly increase traffic on FAP 37 between Interstate 94 (I-94) and Colstrip.

Highway traffic on FAP 39 between I-94 and Colstrip will decline following the end of construction of Units 3 and 4. Increased mining employment and the resulting population increases should push the traffic volume back to near the construction-peak level by the turn of the century (Montana Department of State Lands, 1982, p. III-77). Similarly, traffic on FAP 39 between Colstrip and Lame Deer would increase 88 percent, traffic on FAP 37 between Lame Deer and Ashland would increase 150 percent, and traffic between Ashland and Broadus on FAP 37 would increase 140 percent over 1981 levels.

The capacity of area highways would not be exceeded, but maintenance costs would increase. Traffic volumes along other routes in Rosebud County would increase slightly as a result of the growth in population. All traffic levels would decline greatly after mining ceases.

Four miles of East Fork Castle Rock road would be permanently relocated due to mining in Area C.

3.11.2 Railroad Systems

Railroad traffic on the Burlington Northern would increase due to increased coal production and shipment. Planned expansion of the system includes the Tongue River Railroad and the Otter Creek Spur (Section 3.9) Increased coal movement along Burlington Northern rail lines could cause delays and increased potential for accidents along the routes from the mine to the coal destinations in Minnesota and Wisconsin. Recent grade separations on FAP 39 should alleviate most of the conjection and accident potential near the mine. Regionally, the great distances traversed and widely varying conditions along the routes preclude a specific discussion of impacts that may be felt. Negative impacts that could occur include losses of wildlife and livestock due to train-animal collisions, increased noise levels, and increased gaseous and particulate air pollution levels. Beneficial impacts include increased employment, income to the railroad, and property tax revenues directly attributable to railroad property.

3.11.3 Other Systems

About eight miles of transmission line would have to be moved during mining in Areas B and C. No other impacts are anticipated.

3.11.4 Northern Cheyenne Reservation

The projected coal mining near Ashland would result in increases in traffic using highways that cross the Northern Cheyenne Reservation (Montana Department of State Lands, 1982). These highways, FAP 37 and FAP 39, are maintained by the State of Montana so that increased highway maintenance costs would not affect the Northern Cheyenne Tribal Government. The increase in traffic would result in an increased potential of highway accidents which could result in an increase in the costs of operating the Northern Cheyenne ambulance service.

A very small part of the anticipated increase in traffic on FAP 39 would result from the projected increase in the number of Northern Cheyenne employed at the Rosebud Mine.

3.11.5 Mitigations

The current improvements to FAP 39 between I-94 and Colstrip should eliminate the potential for rail and highway traffic accidents.

State and county law enforcement officials should increase their traffic law enforcement efforts, particularly on U.S. 212 between Lame Deer and Ashland. This would reduce the potential for highway accidents due to increased commuter traffic.

3.12 RECREATION

3.12.1 Urban Recreation Resources

The planned additional parks and recreational facilities discussed in Section 2.12 would be required to meet Colstrip's projected population of about 8,000 in 1983 and its permanent population of 4,500 (1980 Update of the Rosebud County Plan). At the present time, the CARPA recreational resources and facilities are used in capacity, and the future needs will not be met even with the completion of Stillwater Park in the fall of 1982 (Noyd, 1982). However, long-term recreational needs have been incorporated into Colstrip's Master Plan and should be met with the addition of the Castle Rock Course, Equestrian Area, and South Park ballfields.

The out-migration of workers after the completion of Colstrip Generating Units 3 & 4 should help alleviate some crowding of recreational resources.

3.12.2 Nonurban Recreation Resources

According to the Montana Department of Fish and Game (SCORP, 1978), the influx of people into Rosebud County has resulted in greater restrictions of access to private lands than in any other part of southeastern Montana. Many areas previously open to hunting are no longer available. This may create a lack of huntable populations of mule deer and whitetailed deer. Populations of other game animals are expected to adequately meet increased demand.

Fishing near Colstrip is expected to be adequate to meet or exceed the increased demand.

Other nonurban recreation resources are expected to be adequate to meet increased demand.

3.12.3 Mitigations

Recreation impacts might be mitigated by the companies providing indoor or outdoor recreation facilities in communites where employees live. Local government and companies could encourage park land dedication in new subdivisions. Companies could also participate in "adopt-a-park" or other park promotion activities.

3.13 CULTURAL RESOURCES

The Rosebud Mine will result in two types of impacts to cultural resources: direct and indirect. (See Tables 3.13-1 through 3.13-6.) Direct impact is the destruction or damage of a cultural resource site by mining activities. Direct impacts would occur and have already occurred in parts of Areas A-E. Indirect impacts primarily include blasting, which may damage sites within a mile of a blast. The seismic effects of blasting may reach sites in the buffer zone that contain rock art, rock shelters, or standing structures. Damage to these sites may include rock fall within rock shelters, exfoliation of rock art, and weakening of standing structures.

3.13.1 Mining Areas A-E

Of the 69 sites within Areas A-E, 46 would probably be destroyed by mining, 11 would probably be destroyed by associated surface disturbance or recontouring, and 10 would not be directly affected. The exact location of 2 sites in Area B (24RB103 and 24RB327) is not possible to verify, and the impact upon these sites cannot, therefore, be assessed. The Farley Ridge Site (24RB1022) in Area A has been previously mined and regraded.

Five sites within Areas A-E contain rock art. Four of the 5 sites may be destroyed by mining. The remaining site, Alan's Petroglyph (24RB266), in Mining Area E, was badly eroded in 1971 and 1973 and disappeared by 1979.

Of the 46 sites that may be destroyed by mining, 6 have been determined eligible, 17 have been determined ineligible, 3 appear to be eligible, and 18 do not appear to be eligible for the National Register of Historic Places (NRHP). Additional work is required before NRHP eligibility determinations can be made on the remaining 2 sites.

Of the 11 sites that may be damaged or destroyed by surface disturbance or recontouring, 1 has been determined eligible, 1 has been determined ineligible, 2 appear to be eligible, and 7 do not appear to be eligible for the NRHP. It should be noted that all of the NRHP evaluations are based on current significance criteria and contemporary archeological methods. Should these parameters change, the NRHP eligibility of the sites also may change.

3.13.2 Buffer Zone

Sixteen of the 41 sites within the buffer zone contain rock art, rock shelters, or standing structures and could be damaged by the seismic effects of blasting. (See Table 3.13-7.) Of the 16 sites, 4 have been determined eligible, 2 have been determined ineligible, 4 appear to be eligible, and 4 do not appear to be eligible for the NRHP. No information is available on the NRHP eligibility for the remaining 2 sites. Portions of the buffer zone have not been surveyed, and additional sites may exist.

TABLE 3.13-1

TOTAL CULTURAL RESOURCE IMPACTS BY AREA

AREA	DESTRUCTION BY MINING	DESTRUCTION OR IMPACT BY SURFACE DISTURBANCE AND/OR RECONTOURING	NO DIRECT IMPACT	OTHER
A	3	1	2	1 in "previously mined and graded area"
B	4	0	1	2 exact location unknown
C	21	2	4	0
D	18	10	0	0
E	0	0	1	0

TABLE 3.13-2

SUMMMARY OF IMPACT TO CULTURAL RESOURCES:
MINING AREA A (6 SITES)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
1	24RB276	Sly Bison Site	Bison kill and processing area	E	X		
2	24RB105	Cattail Site	Lithic scatter	-	X		
3	24RB1019	Ellison Petroglyph Site	Prehistoric petroglyph	E		X	
4	24RB1020	Ellison Rock Site	Habitation	E		X	
5	24RB1022	Farley Ridge Site	Lookout/lithic scatter	I		X (already destroyed)	
6	24RB1033	Western Energy Shelter Site	Rock shelter w/lithic and historic debris	-		X	

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981

E = Determined Eligible
I = Determined Ineligible
- = Recommended as Ineligible by Consultant

TABLE 3.13-3

SUMMARY OF IMPACT TO CULTURAL RESOURCES:
MINING AREA B (7 SITES)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
1	24RB95	West Homestead Site	Historic Homestead	I	X		
2	24RB96	Well Collected Site	Campsite/ lookout	I		X	
3	24RB252	How Dry I Am Site	Temporary Campsite	I		X	
4	24RB270	R.S. Kimball Site	Open occupation	I		X	
5	24RB327	No Information Site	Lithic scatter/rings	NI			
6	24RB4014	Old Homestead Site and Kill	Bison Kill	I		X	
7	24RB1031	No Information	Rock shelter	NI			

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981

I = Determined Ineligible
NI = No Information; exact site unknown - cannot assess impact

TABLE 3.13-4

SUMMARY OF IMPACT TO CULTURAL RESOURCES:
MINING AREA C (37 SITES)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
1	24RB299	Fadhl Kill	Bison Kill	E		X	
2	24RB874	In Site	Occupation/ habitation	E		X	
3	24RB875	P.E. Davis Rock Art Site	Prehistoric and historic rock art	I		X	
4	24RB876	Wheatfield Vista Site	Occupation/ lithic scatter	I		X	
5	24RB877	Connie's Gallery Site	Prehistoric and historic rock art	I		X	
6	24RB878	Foresite	Rock shelter	NRG-AWR		X	
7	24RB879	Medicine Root Site	Occupation/ lithic scatter	NRG-AWR		X	
8	24RB880	Pigeon Site	Occupation/ lithic scatter	I		X	
9	24RB881	Sunburn-Out Site	Hunting/lookout lithic scatter	I		X	
10	24RB882	Gar Vadar Site	Stone circle/ lithic scatter	NRG-AWR	X		
11	24RB883	Normand Estates Site	Occupation/ hunting camp	I			X
12	24RB884	Fadhl Homestead Site	Historic homestead	E	X		
13	24RB885	Albino Deer Site	Lithic work area	I	X		
14	24RB886	East Fork Site	Lithic work area	NRG-AWR	X		
15	24RB887	Tripoint Site	Hunting/lookout	I		X	
16	24RB1058	Farley Lookout Site	Lookout/ occupation	E		X	
17	24RB1059	Cooley Site	Temporary occupation/processing	+		X	
18	24RB1060	Three Ring Site	Stone Circles	I		X	

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981; unmarked sites in Block II of Area C and information is not yet available about potential impacts on these sites.

E = Determined Eligible
I = Determined Ineligible
\+ = Recommended as Eligible by Consultant
NRG-AWR = No Recommendation Given, Additional Work Required

TABLE 3.13-4 (continued)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
19	24RB1061	Rocky Top Site	Temporary occupation	I		X	
20	24RB1062	Pottery Site	Open occupation	I		X	
21	24RB1064	Cooley Place	Historic homestead	E		X	
22	24RB1065	Doc Taylor Place	Historic homestead	E	X		
23	24RB1066	Rasmus Swelk Homestead	Historic homestead	+		X	
24	24RB1067	Caskey 320	Historic homestead	I		X	
25	24RB1069	Dusty Shelter Site	Rock shelter/ lithic debris	I		X	
26	24RB1071	Lynn's Square Site	Rock structure possible vision quest or possibly historic	I		X	
27	24RB1072	Gene's Vision Quest	Rock structure, U-shaped/possible vision quest	I	X		
28	24RB315	Waste of Time	Collapsed dugout	-			
29	24RB326	Buteo Lob Structure	Collapsed log structure	-			
30	24RB328	Pinkerton Homestead	Log cabin, outhouse & shed, cellar	NRG-AWR			
31	24RB331	Model T Homestead	Auto frame, cabin cellar, other structure	-			
32	24RB332	Castle Rock Community Center	House, barn, coop & outhouse	NRG-AWR			
33	24RB334	Flynn Homestead	Cabin, farm equipment & out buildings	NRG-AWR			
34	24RB391	Ashenhurst Monument	Rockpile (sheepherder monument)	-			

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981; unmarked sites in Block II of Area C and information is not yet available about potential impacts on these sites.

E = Determined Eligible
I = Determined Ineligible
+ = Recommended as Eligible by Consultant
- = Recommended as Ineligible by Consultant
NRG-AWR = No Recommendation Given, Additional Work Required

TABLE 3.13-4 (continued)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
35	24RB287	Blackbird Draw Site	Lithic scattering	NRG-AWR			
36	24RB329	Pinkerton Rocks Log Shed	One log shed	NRG-AWR			
37	24RB330	West Fork Homestead	Cabin, barn, cellars, shed, farm equipment & misc. articles	NRG-AWR			

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981; unmarked sites in Block II of Area C and information is not yet available about potential impacts on these sites.

NRG-AWR = No Recommendation Given, Additional Work Required

TABLE 3.13-5

SUMMARY OF IMPACT TO CULTURAL RESOURCES:
MINING AREA D (28 SITES)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
1	24RB863	Beauregard's Lookout Site	Open occupation	−		X	
2	24RB864	Drifter II Site	Open occupation	−		X	
3	24RB866	Kraked Krok Site	Open occupation	−		X	
4	24RB865	Needmore Site	Open occupation/chipping station	+			X
5	24RB859	Right Now Site	Open occupation/lithic scatter	+		X	
6	24RB871	Sandrock Industrial Site	Prehistoric petroglyph/open occupation	+		X	
7	24RB870	Stack View Site	Open occupation			X	
8	24RB861	Three Cluster Site	Open occupation	+		X	
9	24RB860	Three Dead Pine Site	Campsite	−			X
10	24RB[illegible]	Under the Table Site	Open occupation	−		X	
11	24RB867	Undersite Dugout	Historic dugout (storage?)	+		X	

* Based on Exhibits [illegible], Western Energy Company's [illegible]

+ = Recommended as Eligible by Consultant
− = Recommended as Ineligible by Consultant

TABLE 3.13-5 (continued)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
12	24RB476	Prospector Drive Site	Campsite	-		X	
13	24RB478	Power Quarry Site	Material Testings & knapping station	E			X
14	24RB1041	Three Lobe Site	Open occupation	-		X	
15	24RB1042	Departure Site	Open occupation	-		X	
16	24RB1043	Jay Site	Open occupation	-		X	
17	24RB1044	Garbage Site	Open occupation	-		X	
18	24RB1045	Fuzzy Bird Site	Open occupation	-		X	
19	24RB1046	Peter's 12 Site	Open occupation	-			X
20	24RB1047	Forces Site	Open occupation	-		X	
21	24RB1048	Little Deer Site	Open occupation	+			X
22	24RB1049	July 4th Site	Open occupation/lithic scatter	-			X
23	24RB1050	Two Deer Spring Site	Open occupation/lithic scatter	-			X

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981

E = Determined Eligible
\+ = Recommended as Eligible by Consultant
\- = Recommended as Ineligible by Consultant

TABLE 3.13-5 (continued)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
24	24RB1051	Half Site	Open occupation	-			X
25	24RB105	Drifter I Site	Open occupation	+			X
26	24RB1053	Mourning Dove Site	Open occupation	-		X	
27	24RB1057	Horse Canyon Site	Open occupation	-			X
28	24RB1073	Chipping Station Site	Open occupation/material procurement	-		X	

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981

\+ = Recommended as Eligible by Consultant
\- = Recommended as Ineligible by Consultant

TABLE 3.13-6

SUMMMARY OF IMPACT TO CULTURAL RESOURCES:
MINING AREA E (1 SITE)

	Site Number	Site Name	Site Type	NRHP Eligibility	Type of Impact *		
					No Direct Impact	Destruction by Mining	Destruction or Impact by Surface Disturbance and/or Recontouring
1	24RB266	Alan's Petroglyph Site	Prehistoric petroglyph	I	X		

* Based on Exhibits C and D, Western Energy Company's Comprehensive Mine Plan, July 1981

I = Determined Ineligible

TABLE 3.13-7

CULTURAL RESOURCES THAT MAY BE INDIRECTLY IMPACTED BY BLASTING: BUFFER ZONE AREA

	Number	Site Name	Site Type	NRHP Eligibility
1	24RB161	Dead Pine Rock Structures	Three rock structures, possibly vision quest or fortification structures	+
2	24RB162	Tumbled Stead homestead	Historic log cabin	-
3	24RB163	Mellow Winds Shelter	Rock shelter with lithic debris	+
4	24RB253	Tim's Shelter Site	Rock shelter, prehistoric rock art	E
5	24RB292	Little Cave Site	Rock shelter/workshop	+
6	24RB301	Lovelace Memorial Site	Historic and prehistoric rock art/lithics	-
7	24RB302	Petro City Site	Prehistoric petroglyphs/lithic scatter	I
8	24RB313	Muskrat Homestead Site	Historic homestead	E
9	24RB333	Smith Homestead Site	Historic homestead	+
10	24RB335	Castle Rock Post	Historic homestead and post office	E
11	24RB337	Picture Window Homestead	Historic homestead	-
12	24RB392	No Information	Historic homestead	NI
13	24RB393	Sandstone Chimney Homestead	Historic homestead	I
14	24RB1024	Engineer Shelter Site	Rock shelter w/petroglyphs	E
15	24RB1068	Henley Homestead Site	Historic homestead	-
16	24RB1070	Daughtrey Cabin Site	Historic homestead	NI

E = Determined Eligible
I = Determined Ineligible
+ = Recommended as Eligible by Consultant
- = Determined as Ineligible by Consultant
NI = No information

In addition to blasting impacts may occur from vandalism caused by increased population and site accessibility. These impacts, however, cannot be assessed at present. Cumulative impacts to cultural resources could also occur resulting from the Rosebud Mine and other mineral development in the area. These impacts are likely to be significant, because the region is an important national source of coal which will continue to be exploited.

3.13.3 Mitigations

Mitigations for cultural properties can include a number of actions: (1) avoiding destruction of the site, (2) recording any significant information from a site, and (3) preserving significant artifacts.

Western Energy has submitted mitigation plans for a number of sites, including Ellison's Rock, Ellison's Petroglyph, Sly Bison, Fadhal Kill, and Power's Quarry. Mitigation in the form of recording has taken place at numerous sites over many years.

3.14 ESTHETICS

Mining would change the esthetic qualities of the area, and would change them most appreciably during the life of the mine. Colors, textures, contrast, and relief would all be significantly altered during mining and after reclamation. Overall relief would be approximately the same in the reclaimed spoils, but topographic breaks and sandstone and clinker outcrops would be gone. Ponderosa pines in the mine area would also be lost, perhaps permanently, thus altering texture, color, and contrast in the post-mine landscape. The revegetated slopes would have a generally uniform color and texture and, in places, would contrast noticeably with undisturbed areas.

4.0 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY OF THE LANDS AFFECTED BY MINING

Mining from 1980 to 2017 would extract about 377 million tons of coal from the Rosebud seam. Of this total, 185 million tons would fuel Colstrip Generating Units 3 and 4. Coal from Areas A and B would fuel power-generating facilities in the upper Midwest, and coal from Areas D and E would fuel Colstrip Generating Units 1 and 2 and the Corette Generating Plant in Billings. In addition to electricity production, coal mining would produce considerable tax revenues, royalties, and jobs.

If the lands to be mined were left undisturbed, livestock forage, wildlife habitat, winter wheat, hay, marginal forest products, and scenery would continue to be produced. All of these uses would be curtailed during mining, and crop production, wildlife habitat, and scenic value would be temporarily reduced after reclamation.

About 5,500 acres of grazing land would be disturbed over the life of the mine. If it is assumed that all 5,500 would be out of production for the entire life of the mine--an average of 33 years--the "worst case" livestock productivity loss can be calculated. At an average productivity rate of 0.3 AUM's per acre per year, the maximum potential loss in cattle production would total about 5,500 head.

Reductions in long-term vegetative productivity would be minimal or nonexistent. For the short term, maximum potential vegetative productivity of the reclaimed lands would probably not be as high as what could have been achieved prior to mining under optimum management. The slight reduction that could occur could last for several years, caused by the following unavoidable impacts on soils: disruption of the natural soil profile and pore continuity, reduction in infiltration rates, and loss of structure, organic matter, and microorganism populations.

During mining, some air pollutant concentrations would increase. However, even for total suspended particulate (TSP), the increase would be small: all State and Federal standards would be met. When mining ceases, air quality would return to premining conditions.

Mining would degrade shallow groundwater within the mine area and groundwater downgradient from the mine. The degradation would probably not preclude future livestock watering. Spoils water at the mine could, as a general rule, be used for watering cattle and horses, although the animals may have a more restricted range, owing to higher salt content in the water. Closer spacing of watering wells could mitigate this impact.

The headwaters of the ephemeral creeks located east of the mine (Spring, Pony, Cow, South Fork Cow) would eventually receive groundwater with salt levels 1½ to 2 times higher than pre-mining groundwater. Small, localized areas along the upper reaches of these creeks would undergo shallow alluvial groundwater changes that could slightly reduce the vegetative productivity of these areas. More than a couple of miles from the

mine, the adverse effects of mine spoils water would be undetectable, owing to dilution of spoils water by deeper bedrock water and direct surface water infiltration. (See Hydrology, Chapter 3.)

Overall, the land use patterns of the Colstrip area would not be noticeably changed as a result of ground or surface water changes at the mine.

5.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Mining would destroy the natural stratigraphy and topography of the mine area. The stratigraphy is not, however, unusual or distinctive, and the topography after reclamation would be graded to approximately the pre-mine shape.

After reclamation, the McKay coal seam would probably become irretrievable. The seam would lie 70 to 100 feet below the surface. Since the McKay is only 10 feet thick, overburden removal to reach the seam would be uneconomical: whereas most mines in the Rosebud Mine area now have stripping ratios (the number of cubic yards of overburden that must be moved to reach each ton of coal) of 3 or 4, the stripping ratio of the McKay coal would be 7.

Groundwater quality within and downgradient from the mine area would be irreversibly degraded. (See Long-Term Uses Versus Short-Term Productivity.)

Successful establishment of conifers or shrubs is uncertain, and the potential for crop or timber production would be reduced.

During mining, rock outcrops in several parts of the mine area would be removed and could not be replaced. This would eliminate at least one existing site for a golden eagle and prairie falcon nest. Elsewhere, mining would destroy four sharp-tailed grouse dancing sites.

Fifty-seven prehistoric or historic cultural sites within the mine permit area may be destroyed. Twelve of these sites are either eligible or potentially eligible for the National Register of Historic Places (NRHP). All of the eligible sites would be excavated, recorded, and analyzed prior to mining, and this would prevent the information they contain from being irretrievably lost. Not all of the buffer zone has been surveyed, but at least eight sites appear eligible for the NRHP. Indirect impacts (the seismic effects of blasting) could cause the irretrievable loss of these eight sites, but a proper mitigation plan could prevent loss of the information the sites contain.

From 1980 until the end of mining, the mine would use a total of about 100 million gallons of diesel fuel, 6 million gallons of gasoline, 1.7 billion kilowatt hours of electricity, and 2,500 acre-feet of water. Household water consumption by the population stemming from mine employment would total about 360 acre-feet per year.

6.0 CONSULTATION AND COORDINATION

6.1 DEVELOPMENT OF THE FINAL ENVIRONMENTAL IMPACT STUDY

This environmental impact study was prepared by Ertec Rocky Mountain, Inc., under direction of the Montana Department of State Lands and the Office of Surface Mining. Information used in the preparation of this final document was obtained from the following agencies and companies:

Federal Agencies

U.S. Department of Agriculture
- Agricultural Research Service
- Forest Service
- Soil Conservation Service

U.S. Department of Interior
- U.S. Geological Survey
- Bureau of Land Management

State Agencies

Montana Department of Health and Environmental Sciences
Montana Department of Highways
Montana Historical Society - State Historic Preservation Office
Montana Department of State Lands
Montana Department of Natural Resources and Conservation
Wyoming Department of Environmental Quality

Companies

Bison Engineering (Subconsultant - Air Quality)
Western Analysis, Inc. (Subconsultant - Socioeconomics)
Professional Analyst, Inc. (Subconsultant Cultural Resources)

6.2 AUTHORS

The following individuals contributed to the preparation of the study. Ertec's subconsultants included J. Gelhaus and M. Roach (Bison Engineering); D. Bourke, L. Rovig, S. Holtzmann, T. Klack, L. Priest (Western Analysis, Inc.); and A. Fricke and D. Nielsen.[1] Ertec personnel who contributed include:

Adams, S., Vice President, Geology
- ^.B. Geology, Dartmouth College
- A.M. Geology, Dartmouth College
- Ph.D. Geology, Harvard University

[1]In addition, DSL and OSM staff directed revisions to significant portions of the text.

Carmichael, T., Project Archaeologist
- B.A. Anthropology, University of Arizona
- M.A. Cultural Resource Management, University of Arizona

Clark, P., Graphics

Duquet, K., Staff Soil Scientist
- B.S. Botany, Colorado State University

Ellis, J., Administrative Secretary, Word Processing

Hagan, R., Geostatistician
- B.A. Psychology, University of Wyoming
- M.S. Statistics, University of Wyoming

Hagar, F., Project Geohydrologist
- B.S. Engineering Geology, Colorado School of Mines
- E. Geol. Geologic Engineering, Colorado School of Mines

Hall, J., Word Processing

Hansen, E., Project Meteorologist
- B.A. Physical Oceanography, University of Washington
- M.S. Civil Engineering, University of Washington

Hart, T., Staff Hydrogeologist
- B.A. Geography, University of Oxford, England
- Ph.D. (candidate) Geography, University of Colorado

Hastings, T., Project Manager
- B.A. Government, Purdue University
- M.S. Natural Resource Management, Purdue University

Kathol, D., Mining Engineer
- E.M. Mining Engineering, Colorado School of Mines

Macgregor, R., Manager of Life Sciences
- B.A. Biology, University of California
- M.A. Biology, Harvard University

McAvoy, R., Senior Geohydrochemist
- B.S. Chemistry, Bridgewater College

Miles, M., Staff Hydrogeologist
- B.S. Hydrology, Colorado State University

Milliken, L., Senior Geologist
- B.S. Geology, Colorado State University

Muccigrosso, A., Hydrogeologist
- B.S. Geology, State University of New York at Oneonta

Robinson, G., Director of Hydrogeology

- B.S. Geology, Eastern New Mexico State University
- M.S. Hydrogeology, Kent State University

Rybock, J., Director of Environmental Services
- B.A. Psychology, University of Michigan
- M.S. Fisheries, Biology, Oregon State University
- Ph.D. Ecology, University of California

Stoner, D., Project Hydrogeologist
- B.A. Geology, Colgate University
- M.S. Geology, University of Vermont

Stevenson, J., Staff Hydrogeologist
- B.S. Geology, Eastern Michigan University

Thompson, G., Senior Archaeologist
- B.A. Anthropology, University of Washington
- M.A. Anthropology, University of Washington
- Ph.D. Anthropology, University of Washington

White, J., Director of Licensing
- B.A. Geography, California State University, Northridge
- M.A. Geography, California State University, Northridge

Winges, K., Manager of Air Quality and Meteorology
- B.S. Earth and Planetary Science, Massachusetts Institute of Technology
- M.S. Chemical Engineering, University of California

Zweigart, L., Staff Hydrogeologist
- B.S. Geology, State University of New York at Oneonta

7.0 REVIEW OF THIS STUDY

Copies of the draft study were made available to the public for comment. All comments received were carefully considered in the preparation of this final study.

The draft and final studies are available for review in the following places:

- Montana Department of State Lands, Environmental Analysis Bureau (EIS Team), 1539 11th Avenue, Helena, Montana
- Big Horn County Public Library, 419 North Custer Avenue, Hardin, Montana
- Miles City Public Library, 1 South 10th, Miles City, Montana
- The Rosebud County Library, 201 North 9th Avenue, Forsyth, Montana
- Bicentennial Library of Colstrip, 320 Water Avenue, Colstrip, Montana
- Parmley Billings Public Library, 510 North Broadway, Billings, Montana
- Sheridan County Fulmer Public Library, 320 North Brooks, Sheridan, Wyoming
- Montana State Library, 930 East Lyndale Avenue, Helena, Montana
- Office of Surface Mining, 1020 15th Street, Denver, Colorado
- Office of Surface Mining Area Office, 935 Pendell Blvd., Mills, Wyoming

A limited number of copies of the environmental impact statement are available on request from the Department of State Lands, Environmental Analysis Bureau (EIS Team), Capitol Station, Helena, Montana 59620.

Copies of the Technical Support Documentation are on file with the following:

- Montana Department of State Lands, Southern Land Office, 1245 N 29th Street, Billings, Montana.
- Montana Department of State Lands, Environmental Analysis Bureau (EIS Team), 1539 11th Avenue, Helena, Montana.
- Office of Surface Mining, Department of Interior, 1020 15th Street, Denver, Colorado
- Rosebud County Library, 201 North Avenue, Forsyth, Montana.
- Western Energy Company, Colstrip, Montana.

8.0 RESPONSES TO HEARING TESTIMONY AND WRITTEN COMMENTS

#1

NICK GOLDER:

I didn't write out anything particularly here. There was just a few high points I thought I would talk about. I guess I'd start off with ones that I have on the top of things.

A You talked about on page 3-22 putting out new wells, and so forth, and I thought it was pretty good humor when it is supposed to be serious. Actually, I think it is a phenomenal mess, and I think if you turned around 180° and took another shot you wouldn't miss it any farther. How many of you have an idea what they are talking about in there? We've tried to describe it for years, and we're still back to square one on that.

B On page 3-32, I'll read a little ways here at the bottom of the page, "...additive effect of mine spoils passing from one mine area to another could push this average to as high as 4,500 to 5,000 mg/l. Such mine spoil water would be marginally suited for watering cattle and horses, the primary projected post-mining land use. Because higher salt levels would likely increase the water consumption of livestock, more and closer-spaced ground water wells would be needed if spoils water were used." I'd like to just comment on that. I don't think there is a magical number. I'm certain there is not a magical number beyond which cattle will or will not drink water. I've been around places where there is bad water, and some cattle learn to drink it, and some sip it, and occasionally you'll find one that will drink so little of it that they will get sick, and, if you don't get them out of there, they'll die. So I don't know if it is the taste, or tolerance, or what you want to call it, but I do know that if you have bad water, cattle will drink less of it, rather than more, because it has salt in it. And it says so; therefore, put in more wells. But I don't think that will solve the problem. You are talking about things that hit the ranchers' pocketbook. I think quite a lot more study needs to be done on this. This TDS of 10,000--I think it says around 10,000 mg/l is all right for beef cattle, 7,000 for dairy cattle. That TDS is a nice convenient catch-all, but, boy, there is a variety of things that might be dissolved solids there, and I think that I am satisfied that more attention needs to be paid to specific things that are dissolved in there. I think there is one reference to that, I think it said they could stand more sodium chloride than they could some of the other salt in the water. But anyway, from my point of view, TDS is a nice catch-all, but when it gets down to the point of view of trying to run cattle in there, I think you are going to have to look quite a bit closer.

C On page 3-40 it says on the bottom of page 3-40 and on over to 41, "The effects of mining will be overshadowed by dilution and nonmining activities." This deals with, this draft EIS deals with what is happening in the spoils area, in the mining area. This sentence refers to the fact that if all this will be overshadowed by dilution and nonmining activities. Again, from the point of view of folks who live there and try to utilize the land off the mining site it seems to me that if something overshadows everything, or most everything that is in this book, we should deal with what overshadows it. We should deal with the main impact on, that's what we are concerned about, and if the mining activities themselves is (I know I'm a little lost in the syntax here, but apparently a surge pond or a fly ash pond are not called mining activities) but if they are causing the impact, you don't have a hydrology inventory or assessment without including some of the big ones in it. I am pretty disappointed that this leaves out very main things. It did remind of,

#1 Nick Golder

A--See response to letter 11, comment G.

B--See response to letter 11, comment Z.

C--See reorganized and added text, Chapter III, Cumulative Hydrologic Impacts.

C as I read through this, I began to say 'Are they ever going to talk about what is causing the real problems?' And I thought in the Bible where it says Jesus was telling the Pharisees that you would strain at a gnat and swallow a camel.

D On page 3-51, I'll read the last couple paragraphs, I guess. "The eventual discharge of industrial pond seepage (associated with Power Units 1 and 2) into the Cow Creek drainage over the next several hundred years could increase TDS levels in surface waters via alluvial groundwater discharges. During low flow periods the TDS levels of Cow Creek could be noticeably increased. Such increases could reduce vegetative productivity downstream." It is interesting to me that I would like to see some mechanism of compensation if this is accepted. The neighbors downstream do own wild land.

E "Additional salt loading to Cow Creek could occur as a result of construction of a proposed fly ash pond. The pond would contain very saline water with TDS levels as high as 32,000 mg/l (10 times greater than background levels)."

"The rate of seepage from this pond could be as high as 90 gpm which if left unchecked would significantly increase TDS levels of both the Cow Creek alluvium (5 fold) and of the surface waters of Cow Creek. To control this seepage, Montana Power Company has proposed a clay barrier built to bedrock encircling the pond. In addition, numerous ground water withdrawal wells will be placed around the perimeter to capture and recycle seepage water..." I don't know if that is still exactly the deal or not. "As a result, maximum net seepage losses of the pond at the property boundary would be a maximum of 20 gpm." This is 10½ million gallons a year. "This amount of seepage if entered directly into the alluvium of Cow Creek would still raise the TDS levels from around 2,700 to about 6,700 mg/l." I would like to refer back to the other fly ash pond that was given almost no notice in this thing, and I don't recall that they put it in clay there, that they found out a long time ago it doesn't work very well in the bottom of the stockwater tank. Anyway, there is some of that in the bottom of the existing fly ash pond. It also had 32,000 mg/l. I don't know of anybody checking on that, and I would like to see somebody bite the bullet. In fact, that bullet, I'm afraid, has become a major timebomb. I am really disappointed that something as important to the long-term liability of the country downstream there is not really addressed. I did discern in here that the number 1 fly ash pond, depending on which place I did my arithmetic, is either putting out 29 acre-feet per year or 21 acre-feet per year of liquid, and when I compare that to the, say, the bottom ash pond which is a small pond that was supposed to have been sealed (the land is down over by the plant), and it got 13 acre-feet a year out of that small pond, something is awfully wrong with the figures on the existing fly ash pond there. Something doesn't add up. But, anyway, the information is very sketchy, and it is far overdue to do something about that. I don't suppose we'll have something the magnitude of the Love Canal, but it is a shame, too. Humpty Dumpty is hard to put back together after he falls off the wall. It seems like the sooner you get at these things, the less problem will develop, and it doesn't seem to be ethically correct, or morally correct, or something, to just let it go and hope our grandchildren will figure out something. It is hardly what I would encourage anyone to do.

Thank you.

D--See response to letter 11, comment SS.

E--See response C above.

#2

J. R. LEE

A The Comprehensive EIS statement totally avoids analyzing the damage downstream from Colstrip. It carefully avoids it. They draw their maps to where they don't come down there and study the damage that is being done. I wish the State would consider these damages, and I wish you State men when you drive to Colstrip from Forsyth would just look and see what is happening to Armells Creek along the way, when you ride down there. Look at the dead trees, the dead meadows. I may say this, that the reason this does not show up in the area that the map says that you have studied is that there are no low bottoms on Armells Creek. You should go down to where the low bottoms start, and study them, and see how the production has been cut. That is what we have to live with, and I think that, eventually, is what a lot of the downstream areas from the other drainages from the coal mine areas will have to examine.

Thank you.

#2 J.R. Lee

A--The dying trees do not appear to be related to water quality changes--even though alluvial groundwater quality immediately downstream from Colstrip is worse than above. Seepage from the surge pond and surface water discharges from Colstrip's sewage treatment plant are believed to be major sources of additional alluvial groundwater downstream from Colstrip. This additional water causing high groundwater conditions may be the reason for the dying trees downstream from Colstrip. We know of no studies that specifically address these vegetative changes and, therefore, are unable to conclusively determine the cause.

#3

Public Hearing
Re: Draft Comprehensive EIS, proposed by WECo.
May 5, 1983 - Rosebud Co. Courthouse 7 p.m.

Testimony by Patty Kluver, rancher

Anyone involved in Agriculture in eastern Montana is very aware of the importance of good water to their lives and livelihood. When my grandfather, a relatively uneducated man, bought a number of sections from the Northern Pacific in 1901, he knew the area had an abundance of good water, for hay crops; for livestock, and for domestic purposes. However, in 1923, the railroad exercised the reservation contained in the deed, for coal and iron. He reluctantly sold it back to them, along with the even numbered sections he'd acquired for his Red Buttes ranch.

My grandfather knew the area was underlain with coal, and he knew the importance of the coal to the groundwater of the region. That is why it was almost amusing to read, (p. 3-20, Hydrology: "Coal has a high oranic matter content and therefore appears to absorb some of the constituents in groundwater. The net result may be to lower the TDS values, improving the quality of the spoils water that passes through the unmined coal. More research needs to be conducted on this subject before quantitive and conclusive statements can be given." A

Charcoal is used to filter water in water plants obtaining water from rivers. It has been used as a filter for a long, long time, but, "more research is needed." How much more is needed? Will the length of time extend to the last bucket of coal mined in the Rosebud mine.

"hat my grandfather knew in 1901, the U. S. Government must have known in 1923. When they sent geologists to this region, they also sent a Hydrologist. His name was Colman Renick.

It appears it was Mr. Renick who named the water bearing coal seams. Most of them were named for the landowner where the water was first sampled, but with the vein at Colstrip, he had no choice. He called it the Rosebud vein, because it's waters not only sub-irrigated the valley, but some of it's water was in the wells used for domestic purposes. That is why the coal vein lying in the upper reaches of the e. f. of Armells creek is called the Rosebud coal vein. B

Responses to Public Hearing Testimony

#3 Patty Kluver

A--The Water Resources Division, U.S. Geological Survey, in Helena, is studying water quality changes of spoils water passing through coal. The report will probably be released in the fall or early winter of 1983.

B--Mr. Renick's study listed only one bedrock groundwater well sample in the Cow Creek drainage. That single well sample, located far from the mine area, tells us nothing about mining affects on water quality. In fact, Renick's report eludes to the naturally poor quality of surface water runoff in tributaries to Rosebud Creek. Unfortunately, he did not supply the specific data he used to formulate this conclusion. Even so, one sample taken on a well, or especially of surface-water runoff, tells us very little because the quality generally changes from day to day and from year to year. Long-term baseline studies of bedrock alluvial and surface water quality would be very helpful in determining mining-related change, but, unfortunately, no such information is available.

2

[redacted]

At the meeting with ERTEC, sponsored by DSL, it was my understanding that this was to be a treatise employing all the known works of Hydrology. Is the work of Renick mentioned on a single page?

After all, Colman Renick's study is the only one of pre-mining origin! In all the rest, the water seeping from the mined pits has already contaminated considerable acreage, in the e. f. of Armells creek, and in Cow Creek.

Cow Creek is mentioned rather frequently in the Hydrology section. It would imply that the water of that tributary to Rosebud creek has always been bad.

In Mr. Renick's study, a township by township sampling of wells across the area, at the headwaters of Cow Creek, the average TDS was 843, an excellent quality of water. It is a far cry from that measured today, upward from 3000 TDS, and the Boron measurement [redacted] is missing.

Of course, Boronis measured in micrograms per liter, while I can find only milligrams measured in this EIS. It takes one thousand micrograms to make a milligram. Boron measured 3700 micrograms, multiplied a thousand times would make quite an equation, but that is what has happened to the waters of Cow creek. It happened to the pine trees surrounding the ash pond for 1 and 2, last winter, also, They died, almost over night, when they were sprayed with Boron laden ash water.

And, that is probably what has happened to the tree skeletons along the .e f. Armells creek.

The officials of DSL have known since the beginning of the importance; the correlation between the coal and groundwater. That is why Mr. Hopkins was sent out to the area in 1972-73. If his was supposed to be a baseline study, it failed. Mr. Hopkins did sample the well on so. Cow Creek, but he didn't take a single test on Cow Creek. Of the well on so. Cow Creek, he told my husband, "It's alright for livestock I guess, but don't ever drink it, yourself." - It is located downstream from the old Rosebud mine of N.P.

C--Boron concentrations appear to be naturally high in the Cow Creek drainage--and have reached 3,700 micrograms per liter. For clarification, this is equivalent to 3.7 milligrams per liter (1 milligram = 1,000 micrograms).

Water containing boron concentrations of more than 0.75 mg/l is not recommended for irrigation (Montana Ground Water Regulations), and yet, much of the natural waters in the region are close to or exceed this level. Boron concentrations in East Fork Armells Creek are generally less than 1 mg/l. However, alluvial water below the confluence of Cow Creek and South Fork Cow Creek contains 2 to 4 mg/l boron. Since industrial sources have not reached Cow Creek and no effects from mining are discernible, the relatively high boron concentrations in Cow Creek must be due to natural causes.

Boron concentrations in bedrock groundwaters adjacent to the existing fly ash evaporation pond and other industrial ponds have more than doubled. Slight increases in boron levels in both Cow Creek and East Fork Armells Creek can be expected due to industrial wastewater seepage.

It is doubtful, however, that dead trees downstream from Colstrip are due to seepage out of the fly ash pond, since water quality samples in the East Fork Armells Creek alluvium do not show high boron or TDS levels, average less than 1 mg/l. The trees may have died due to a raised water table. (See response to public hearing #2.)

If DSL continues to issue permits to mine the Rosebud coal vein, what are the ranchers supposed to do with this contaminated water. We can't irrigate with it? We can't feed the chickens, or slop the hogs with the water. It is even extremely questionable for livestock of a larger size, cattle and horses. Yet, it will certainly continue to drain down e. f. Armells creek and Cow Creek.

What are we supposed to do with this destroyed water, so that the Mining Company can continue their destruction, and the 30% severence tax can grow. Has the State Land Department [redacted] an answer? I'd like to hear it?

In mining Area C, containing Cadmium, Molydbenum, Boron, and other noxious elements, the sub-surface soil is put in the bottom of the pit, so that the ground water can flow through it, or down into the McKay vein, more full of sulfate, and the above named metals and minerals. That is the junk that is left for the off site landowners.

Meanwhile, the coal will be burned; the ashes deposited on a huge sandstone ridge, so that the concentration of those objectionable elements of nature can flow down, beneath the surface, to contaminate still further away, perhaps at Ashland, or the reservation, as Mr. Renick speculated.

DSL promised us a regional Hydrology study. Where is it? This one, like all the others issued by the mining interests, confines itself to the mine proper. It worries about the affect those elements might have on the reclamation, [redacted] but makes [redacted]. no examination of us-

Is the consequences of mining the Rosebud coal; the destruction of the filtering aquifer; the dumping of a toxic waste substance down syncline from the Industry that made it, of no concern to DSL? If it is, prove it by ~~[redacted]~~ conducting a regional Hydrology study BEFORE any more permits for mining are ~~issued~~.

Federal law reads: "Alandowner may not encroach upon the property of his neighbor. He may not use or misuse his property in such a way as to cause harm to the property of a neighbor."

If the State's toughest Reclamation laws in the U.S.A. are so weak that DSL can't find a way to reject the applications, go look in the Federal landowner laws. The answer is

D--Our analysis does not show significant degradation in the quality of the alluvial groundwater or surface waters in the middle and lower reaches of Cow Creek.

E--Analysis of water quality sample of mine spoils indicates that trace metal concentrations are not increased significantly above pre-mining levels.

F--Existing industrial ponds associated with Colstrip Power Units 1 and 2 have increased TDS and boron levels well above background concentrations. The proposed industrial ponds may do the same. (See Chapter III, Section 3.2.3, Cumulative Hydrologic Impacts.)

G--See Chapter III, Section 3.2.3

H--Thank you for your suggestion. Please see comment letter #11, response DD and V.

available to you there.

Thank you,

Patty Kluver

Letter 1

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Ecological Services
Federal Building, Room 3035
316 North 26th Street
Billings, Montana 59101-1396

IN REPLY REFER TO:
ES

April 5, 1983

RECEIVED
APR 06 1983
STATE LANDS

Mr. Dennis Hemmer, Commissioner
Montana Department of State Lands
Capitol Station
1625 Eleventh Avenue
Helena, MT 59601

ATTENTION: Kit Walther

Dear Mr. Hemmer:

We have reviewed the Draft Environmental Impact Statement on Western Energy Company's Comprehensive Plan for the Rosebud Mine and concur in the findings of the biological assessment for listed threatened and endangered species which may be present in the project area. We also believe that future actions identified in the comprehensive DEIS will require additional review and compliance with the Endangered Species Act.

In that regard, Section 7(c) of the Endangered Species Act as amended, requires that Federal agencies which are involved in actions requiring preparation of an Environmental Impact Statement, contact the Fish and Wildlife Service and obtain a listing of listed and proposed threatened and endangered species that may be present in the project area covered by the EIS. After obtaining the list, the Act requires that the agency conduct and submit to the Fish and Wildlife Service a biological assessment describing the effects of the proposed project on listed and proposed species.

If not initiated within 90 days, the list should be verified with the FWS prior to initiation of the assessment. The biological assessment should be completed within 180 days of initiation, but can be extended by mutual agreement between the agency and the FWS. The assessment conducted pursuant to Section 7(c) may be undertaken as part of the agency's compliance with the requirements of Section 102 of NEPA and incorporated into the draft EIS.

Thank you for reviewing the statement and clarifying the Federal agencies' responsibilities under the Endangered Species Act, the Migratory Bird Treaty Act, and Bald Eagle Protection Act.

8-9

Upon completion of the assessment, if the agency determines that the project will affect any of the above-listed species, formal consultation with the FWS through our Endangered Species Office should be initiated. If the agency determines that any proposed species may be affected, an informal conference with our Endangered Species Team should be initiated to discuss measures that can be taken for their conservation. Section 7(d) of the Act requires that during the consultation process, the Federal agency and the permit or license applicant shall not make any irreversible or irretrievable commitment of resources which would preclude the formulation of reasonable and prudent alternatives.

We also wish to take this opportunity to emphasize that some of the projected activities impacting nesting migratory birds and their habitats are regulated by the Migratory Bird Treaty Act and the Bald Eagle Protection Act. Compliance with these acts will require that a special purpose permit be obtained from the U.S. Fish and Wildlife Service prior to disturbance of the migratory bird nests.

We appreciate the opportunity to review and comment on the DEIS for the Rosebud Mine.

Sincerely,

John G. Wood
Field Supervisor
Ecological Services

cc: Director, Montana Department of Fish, Wildlife, and Parks, Helena, MT
Regional Director, USFWS, Denver, CO (HR)
Regional Director, OSM, Denver, CO

Letter 2

MONTANA HISTORICAL SOCIETY

HISTORIC PRESERVATION OFFICE

225 NORTH ROBERTS STREET • (406) 449-4584 • HELENA, MONTANA 59601

April 7, 1983

APR 1 1 1983

Mr. Kit Walther
EIS Team Leader
Capitol Station
Helena, MT 59620

Dear Mr. Walther:

RE: DEIS Western Energy Company's Comprehensive Plan for the Rosebud Mine.

A Thank you for the opportunity to review the subject document. I found the information on cultural resources and the format in which it is presented to be extremely useful in examining the scope of previous survey and site investigations and in formulating a basic outline of work that remains to be done in all mine plan areas and the surrounding buffer zone. The DEIS indicates

B that portions of Area C have not been intensively surveyed and that there are numerous gaps in the buffer zone coverage. The appropriate level of survey should be authorized in the immediate future to ensure that no cultrual resources are impacted during the course of mining operations.

C It became apparent during my review of the DEIS that the subcontractor had more complete, up-to-date information than was available in our office files on which sites are in which areas, blocks and buffer zone. To double-check all site data would have been a duplicative and probably unproductive effort on our part. I did notice some conflicting information and wanted to point this out--in almost all cases this office's files likely need to be corrected.

D In Area A, our files show these sites to be in the direct impact area:

24RB1065-Doc Taylor homestead; 24RB313-Muskrat homestead; 24RB95-West homestead; 24RB452-B&R homestead; 14RB454-Reservoir homestead; 24RE163-Mellow Winds Shelter. The first two sites listed were determined eligible for listing on the National Register of Historic Places, by the Keeper of the National Register. The other four sites were recommended eligible by MRC in the 1979 report on Area A and Extension.

E Area B

Site 24RB95-West homestead site, is shown in Table 2.13-3 to be in the direct impact area. Reference please my letter of 8/11/82 to Dallas Owens in which the potential eligibility of this site is dis-

A--Your comment is noted. Thank you.

B--Thank you for your comments. In the future it would be useful to have specific pages referenced. Those portions of Area C which have not been intensively surveyed, or which have not had the adjacent buffer survey completed are in Block II, for which no mine plan has been proposed. The Department cannot require a survey prior to receipt of an application. However, if or when an application is received, the baseline studies will include an intensive cultural survey of the area to be permitted, as well as a survey of the complete buffer zone.

The gaps in the Area D buffer are because landowner permission for access could not be obtained. The Area E buffer was not surveyed because buffer surveys were not required at the time the adjacent portion of Area E was permitted. A 1-mile buffer survey was completed for Area A (Application #00107), although this is not indicated on the map on page 2-155 of the draft.

C--Your comment is noted. Thank you.

D--The Area C buffer would be surveyed when application is made for a permit to disturb the adjacent area. These sites will not be directly impacted. The West homestead, for instance, is between two direct impact areas but will not be disturbed. The same is true of the Doc Taylor and Muskrat. The most recent report shows the B & R homestead and the Reservoir homestead are actually buffer zone sites. Mellow Winds Shelter is within the permit boundary but outside the disturbance area.

E--Please refer to response B. In summary, the West homestead will not be disturbed, although this does not show on maps at the scale used for this document.

E cussed. This site was presumed to be in the buffer zone of Area B, and no formal determination of eligibility has been requested, nor were any specific preservation measures discussed.

Area C

F Here I'll have to admit my confusion over the Block I & II designations in this mining area. Many of the sites listed as lying in the direct impact area are reported in the DEIS on Area C Block I as buffer zone sites. These are: 24RB875-P.E. Davis Rock Art Site, 24RB876 Wheatland Vista Site, 24RB877-Connie's Gallery Site, 24RB880-Pigeon Site, 24RB881-Sunburn-out Site, 24RB882-Gar Vader Site, 24RB883-Normand Estates Site, 24RB885-Albino Deer Site, 24RB-East Fork Site, 24RB1061-Rocky Top Site, 24RB1062-Pottery Site, 24RB1065-Doc Taylor Place, 24RB1069-Dusty Shelter Site. Should these sites be considered to lie within the direct impact zone of Area C?

G Please note that the site designations for the Tripoint Site and Farley Lookout Site are incorrect. The correct Smithsonian designations are 24RB873 and 24RB1058, respectively. Two "minimal activity loci" # 1401 and 1704 warrent further work such as testing and/or recordation. Numerous historic sites contained in our Area C files were not listed in Table 2.13-4. These are: 24RB313-Waste of Time. 24RB326-Buteo log structure, 24RB328-Pinkerton homestead, 24RB329-Pinkerton Rock log structure, 24RB330-West Fork homestead, 24RB331-Model T homestead, 24RB332-Castle Rock Community Center, 24RB333-Smith homestead, 24RB334-Flynn homestead, 24RB391-Ashenhurst Monument, 24RB335-Castle Rock Post Office, 24RB873, and 24RB888. The Blackbird Draw Site (24RB287), an archaeological site, is reported to lie in Area C Block II and appears to have National Register potential. The Rasmus Sweik homestead, 24RB1066, was re-inventoried in November, 1982, by Kurt Schweigert as part of a systematic Montana homestead study. It was discovered that some of the structural features had been removed relatively recently. Some additional work is required before an assessment of site significance can be made.

H

I According to this office's files, site 24RB868 (Show me Site) is situated in Area D. This site is listed in the buffer zone or indirect impact area under Table 2.13-7 without a site number. The Power Quarry site(24RB478), was officially determined eligible for National Register listing, but since that time has sustained damage from erosion and the movement of heavy equipment over the site and adjacent land surfaces. I have not yet received any report of the results of additional investigations at this site, but I suspect that a reassessment of Register eligibility may be warranted.

J Site number 24RB290, Pine Fringe, should be added to the list of buffer zone sites in Table 2.13-7. This site was reviewed with

F--None of these sites lies within the direct impact area of Block I. When a permit application is received for Block II, an evaluation of these sites will be completed. Because Block II is adjacent to Block I, part of the Block I buffer zone is, in all likelihood, Block II direct impact. However, all sites lie within Area C.

G--The two incorrect site numbers are changed in Table 2.13-4. 2-160. Based on consultation with SHPO, the Department is aware that if any disturbance to MAL #1401 is planned further work is warranted. However, until Western Energy formally proposes to disturb the site, the Department cannot require additional work. The same is true of MAL #1704.

H--The Smith homestead (24RB333) and Castle Rock Post Office (24RB335) are in the buffer zone area and are presented in Table 2.13-7. Site 24RB873, the Tripoint Site referred to in question E, is presented as the 15th site in Table 2.13-4. The remaining sites are in Area C, Block II, for which there is no application. They should indeed have been in this table but were omitted. Please see revised tables. Thank you for the additional information on the Blackbird Draw Site (24RB287) and the Rasmus Sweik homestead (24RB1066). Please note that the Smithsonian Designation for Waste of Time is 24RB315 and that 24RB888 (Black Buffalo) is located outside of the Rosebud Mine area.

I--Thank you for the information. See text change.

J--This environmental impact study was prepared at a single point in time. As evaluations are completed or as mine plans change, the document is unable to reflect any such changes. Further, Area C, Block II, and other sections of this document are based on long-term plans which are subject to change.

J Area C materials and appears to meet the minimum qualifications for National Register listing.

K Notwithstanding some of the discrepancies noted above which may be a result of this office's misinformation on sites situated in direct impact areas as opposed to buffer zones, the discussion and tables presented in Chapter 3 on impacts appear to be in order. Western Energy and its cultural resource contractor have consulted with our office on a steady basis on matters of site significance and impact assessments. Though compliance with the appropriate historic preservation regulations is not yet completed, sound progress is being made toward ensuring that cultural resources are fully considered in the planning of the Rosebud Mine.

Thank you for the opportunity to comment.

Sincerely,

Marcella Sherfy

Marcella Sherfy
Deputy SHPO

DV:md

K--Your comment is noted. Thank you.

DEPARTMENT [redacted]NTAL SCIENCES

ENVIRONMENTAL SCIENCES DIVISION

Letter 3

TED SCHWINDEN, GOVERNOR — COGSWELL BUILDING

STATE OF MONTANA

(406) 449-3948 — HELENA, MONTANA 59620

April 6, 1983

Kit Walther
EIS Team Leader
Dept. of State Lands
Capitol Station
Helena, MT 59601

APR 1 1 1983

Dear Kit:

The Department of Health and Environmental Sciences (DHES) has reviewed the environmental health aspects for the draft addendum environmental impact statement (EIS) for Western Energy Company's Rosebud Mine - Area B, Second Extension and the draft comprehensive EIS for Western Energy Company's Rosebud Mine. The DHES staff did not have any comments.

Thank you for the opportunity to review the impact statements.

Sincerely,

Tom

Thomas M. Ellerhoff
Technical Writer

JG

Thank you for commenting.

8-14

AN EQUAL OPPORTUNITY EMPLOYER

Letter 4

United States Department of the Interior

BUREAU OF RECLAMATION
Upper Missouri Region
P.O. Box 2553
Billings, Montana 59103

IN REPLY
REFER TO: UM-150

APR 14 1983

APR 13 1983

Mr. Kit Walther
EIS Team Leader
Department of State Lands
Capital Station
Helena, MT 59620

Dear Mr. Walther:

The proposed mine plan covered by the Draft Comprehensive Environmental Impact Statement - Western Energy Company's Rosebud Mine (DES 83/14) should have no affect on the Bureau's projects in Montana.

Thank you for reviewing the statement.

Sincerely yours,

D S Lauver
D. S. Lauver

For Joseph B. Marcotte, Jr.
Regional Director

8-15

Letter 5

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Miles City District Office
P.O. Box 940
Miles City, Montana 59301

IN REPLY REFER TO 1790

MAY 04 1983

Mr. Kit Walther
EIS Team Leader
Department of State Lands
Capitol Station
Helena, Montana 59620

Dear Mr. Walther:

The Miles City District Office of the BLM has reviewed the Comprehensive DEIS for the Western Energy Company's Rosebud Mine. Our comments are as follows:

A Page 1.7; Figure 1.2-4 should include the new Federal Coal leases issued to Western Energy Company as a result of the 1982 coal lease sale.

B Page 2-4; Section 2.1.2, second paragraph states that the total thickness of the Ft. Union formation at Colstrip is 445 feet. If 360 feet of this is Tongue River Member, as stated, then there is only 85 feet of Lebo and Tullock strata. This we believe is incorrect. Lewis and Hotchkiss (1981) maps show 200 feet of Lebo and 350 feet of Tullock at Colstrip and a base elevation of the Ft. Union formation at 2,400 feet above sea level. This would indicate that the Ft. Union strata are approximately 900 feet thick, not 445 feet.

C Page 2-8; Section 2.1.8, second paragraph. There is no oil production on Porcupine Dome. Production is on the Sumatra Anticline, 20 to 40 miles west of the Dome.

D Page 2-62; It appears the first sentence should read "1,190 cubic feet per day or 10 acre feet per year", not "1,190 acre feet per day."

E Page 2-71 to 2-76; Section 2.4. It would be beneficial to state what, if any, affect the Rosebud Mine has on the Northern Cheyenne Class I air quality designation.

F Page 2-115, second full paragraph. The 1980 population of the Northern Cheyenne Indian Reservation shown is only the population in Rosebud County. There are an additional 1,017 people in Big Horn County according to the 1980 census. This will change all figures used in this paragraph.

G Page 2-126; Section 2.9.3.10.2, third paragraph. Of the 450 more units under construction, are they permanent or temporary?

A--Figure 1.2-4 has been revised as per your comment.

B--The thicknesses of the Fort Union Formation and the Tongue River Member have been changed as per your comment.

C--The text has been changed as per your comment.

D--The text has been changed as per your comment.

E--As stated on page 3-60 of the draft, "air quality impacts in the Northern Cheyenne Indian Reservation from continued mining in Colstrip were calculated to be negligible."

F--You are correct. See text change. 2-115.

G--The 450 units are temporary. See text change.

H Page 2-131, third paragraph. Indian Ashland has two municipal wells. One is in "Rabbittown", the other at the St. Labre Mission.

I Page 2-133, second paragraph, line 8. Is 0.15 percent correct or should it be 15 percent?

J Chapter 3. A mitigation section is provided for 3.1, but not for 3.2 through 3.14. A section on mitigation would be helpful in assessing how impacts are to be lessened.

K Page 3-1, Section 3.1.1. No mention is made of the loss of the sandstone outcrop in the mine area.

L Page 3-54, Table 3.4-1. Why are Colstrip Units 3 and 4 shown to produce 3.5 times the particulate emissions of Units 1 and 2 when they are only twice the size?

Thank you for the opportunity to review the DEIS. We hope our comments will be of help to you in preparing the FEIS.

Sincerely yours,

Bruce G. Whitmarsh

District Manager

ACTING

H--Thank you for the additional information. See text change.

I--0.15 percent is correct.

J--Mitigation measures have been added to the end of the Chapter III, Section 3.2, Hydrology, and other sections.

K--A brief statement has been added to the text regarding removal of sandstone outcrops.

L--The particulate emissions from Colstrip Units 1 and 2 in 1980 are based on actual stack tests and operating hours. For the 1988 Units 1 and 2 particulate emissions, the operating time was increased from 82 percent to 95 percent; hence, the increase in emissions. The 1988 Units 3 and 4 particulate emissions are the "worst-case" allowable emissions, assuming 100-percent availability. Actual particulate emissions would be lower, inasmuch as Units 3 and 4 would not be operating 100 percent of the time at 100 percent capacity, and the scrubbers may be more than 99.5 percent efficient.

Letter 6

HRA HISTORICAL RESEARCH ASSOCIATES
P.O. Box 7086
Missoula, Montana 59807 (406) 721-1958

May 9, 1983

MAY - 0 1983

Mr. Kit Walther
EIS Team Leader
Department of State Lands
Capitol Station
Helena, MT 59620

Dear Mr. Walther:

We appreciate this opportunity to review and comment upon the Draft Environmental Impact Statement for Western Energy Company's Rosebud Mine.

A Section 3.9.1 provides a discussion of the economic and demographic impacts that would occur from mining and related development including the proposed Tongue River Railroad. Current construction plans for the Tongue River Railroad call for construction to begin in 1985 and continue into 1989.

B The composition of the railroad construction work force is expected to be 40 percent local and 60 percent non-local, rather than 60 percent local and 40 percent non-local as cited on page 3-90.

C Section 3.11.2 discusses the potential impacts of increased railroad traffic in the area, including traffic over the proposed Tongue River Railroad. Beneficial impacts of such a line are not limited to increased employment and income to the railroad itself. Those counties in which the Tongue River Railroad would be built would benefit from significant tax revenues directly attributable to railroad property taxes. Further, track maintenance costs are an internal function of the railroad company, and in the case of the Tongue River Railroad have been included in the planning process. This does not realistically qualify as an "impact" of railroad development.

Thank you for the opportunity to make these comments.

Sincerely,

Alan S. Newell

ASN:rh

A--Thank you for the updated information.

B--Thank you for the correction. The text has been revised.

C--Thank you for your comment. The text has been revised.

Letter 7

DIAMOND RANCH
RUSSELL AND GENIE MAY GARFIELD
FORSYTH, MONTANA 59327

May 8, 1983

KD

MAY 10 1983

Mr. Kit Walther
EIS Team Leader
Dept. of State Lands
Capitol Station
Helena, Montana 59620

Dear Mr. Walther:

My comment relates to page 56 of the Draft Comprehensive Environmental Impact Statement, 2.2.2.6 Surface Water Use:

A As this above described paragraph relates to Pony Creek, Sections 29 and 30, Township 2N, Range 43 E, the statement . . . "Pony Creek surface flows are used for stock watering only . . ." is incorrect and incomplete.

Pony Creek in above mentioned sections is also used for flood irrigation and sub-irrigation of hay fields and pasture. Cossack alfalfa has been growing and intermittently harvested in the alluvial valley floor of Pony Creek in Section 30 since 1919.*

Furthermore, I hold a water right which was filed in 1912 appropriating 5 cubic feet per second of Pony Creek water for irrigation of hay meadows in Section 30, T2N, R43E.

B Included in this Comprehensive E.I.S. should be a report of water quality in Pony Creek, based on tests conducted by the Water Quality Bureau in July, 1981. Mr. Michael Wilson and Mr. Gary Amestoy of DSL stated at a December 16, 1981, meeting that this comprehensive impact study would include hydrology studies for a large area (1,000 sq. miles) surrounding the mining at Colstrip. The implication was that most of the water quality and quantity reports gathered over the past few years would be incorporated in this E.I.S. If the report is to be <u>comprehensive</u>, why doesn't it include the July 24, 1981 analysis, as well as many more analyses of water which will surely be impacted by future mining?

Yours truly,

Genie May Garfield

* Personal Communication; May Philbrick, Forsyth, Montana

A--The text has been changed to incorporate your comments.

B--Information on Spring and Pony Creek has been added to appendix B, tables 9, 10, and 11.

DEPARTMENT OF HE TH & HUMAN SERVICES

Office of the
Regional Director

Region VIII
Federal Office Building
1961 Stout Street
Denver CO 80294
ROFEC

Letter 8

May 5, 1983

MAY 09 1983
STATE LAN

Mr. Dennis Hemmer, Commissioner
Montana Department of State Lands
U. S. Office of Surface Mining
Helena, Montana 59620

Dear Mr. Hemmer:

A We have reviewed the Draft Comprehensive Environmental Impact Statement on the Western Energy Company's Rosebud Mine.

As noted in this DEIS, Rosebud County has been awarded a grant by the Montana Coal Board to expand availability of social services in the Colstrip area, and additional staff to be supported by these funds are specified.

So long as supplemental funding is available, social services programs in the area should be able to cope with anticipated service demands. There is no assurance that supplemental funds will be available indefinitely.

B As this document contains no distribution list, we suggest that the Montana Department of Social and Rehabilitation Services be included among State agencies from which comments are solicited.

Sincerely yours,

E. W. McIntire
Director, ROFEC

A--Comment noted, thank you.

B--The Montana Department of Social and Rehabilitation Services is on our mailing list and was mailed a copy.

WESTERN ENERGY COMPANY

115 N. BROADWAY / P.O. BOX 1899 / BILLINGS, MT. 59101 / (406) 252-2277

Letter 9

May 9, 1983

MAY 9 1983

Mr. Kit Walther
EIS Team Leader
Montana Department of State Lands
Capitol Station
Helena, Montana 59620

Re: Western Energy's Comments on the Comprehensive DEIS

Dear Kit:

Attached are our comments on the Rosebud Mine Comprehensive Draft Environmental Impact Statement.

Cordially,

Charles M. Rose

Charles M. Rose
Permit Coordinator
Montana/Wyoming Operations

CMR:kim

attachments

8-21

WESTERN ENERGY COMPANY
Comments: Rosebud Mine Comprehensive Mine Plan
Draft Environmental Impact Statement

1.3 MINING PLAN

1.3.1 Facilities

A

Page: 1 - 5

"These two sites have the same structures: a hopper, primary crusher, secondary crusher, stacker, crushed-coal stockpile, reclaim tunnel, and train loadout."

The Area E mine facilities consist of the following: a hopper, primary crusher, secondary crusher, train loadout and transfer conveyor. The Area A/B mine facilities consist of the following: a hopper, primary crusher, secondary crusher, stacker, crushed-coal stockpile, reclaim tunnel, and train loadout.

A--Your comment is noted. See text change.

2.2 HYDROLOGY

2.2.1.1.1 Rosebud Spoils

B

Page: 2 - 13

"Since the dragline deposits spoils in rows parallel to the stripping operations, spoils exhibit higher permeability* in the direction of the dragline movement. Due to the linear placement of the spoils, permeability* values also vary with direction."

Western Energy Company knows of no factual data to support this statement.

B--You are correct that there are no factual data to support this statement. Rather, the statement is a hypothesis, the basis of which is the rubble zone of larger rock fragments and wasted coal that develops at the base of the spoils. The greater porosity and linearity of this material would seem likely to enhance permeabilities and influence flow direction along the trend of these rubble zones.

2.2.1.1.3 Rosebud Coal Overburden

C

Page: 2 - 15

"Faults and fracturing in the overburden in Area B (Plate B-1, Technical Support Document) could be responsible for the high transmissivity values (79,000 gpd/ft) in that area."

The only faults on Plate B-1 which are not shown as inferred faults are in an area where there is no faulting as shown on the attached cross-sections (See Figures 1-4).

C--The reference to faults in Area B was deleted and replaced with flexures as your attached cross-sections indicate.

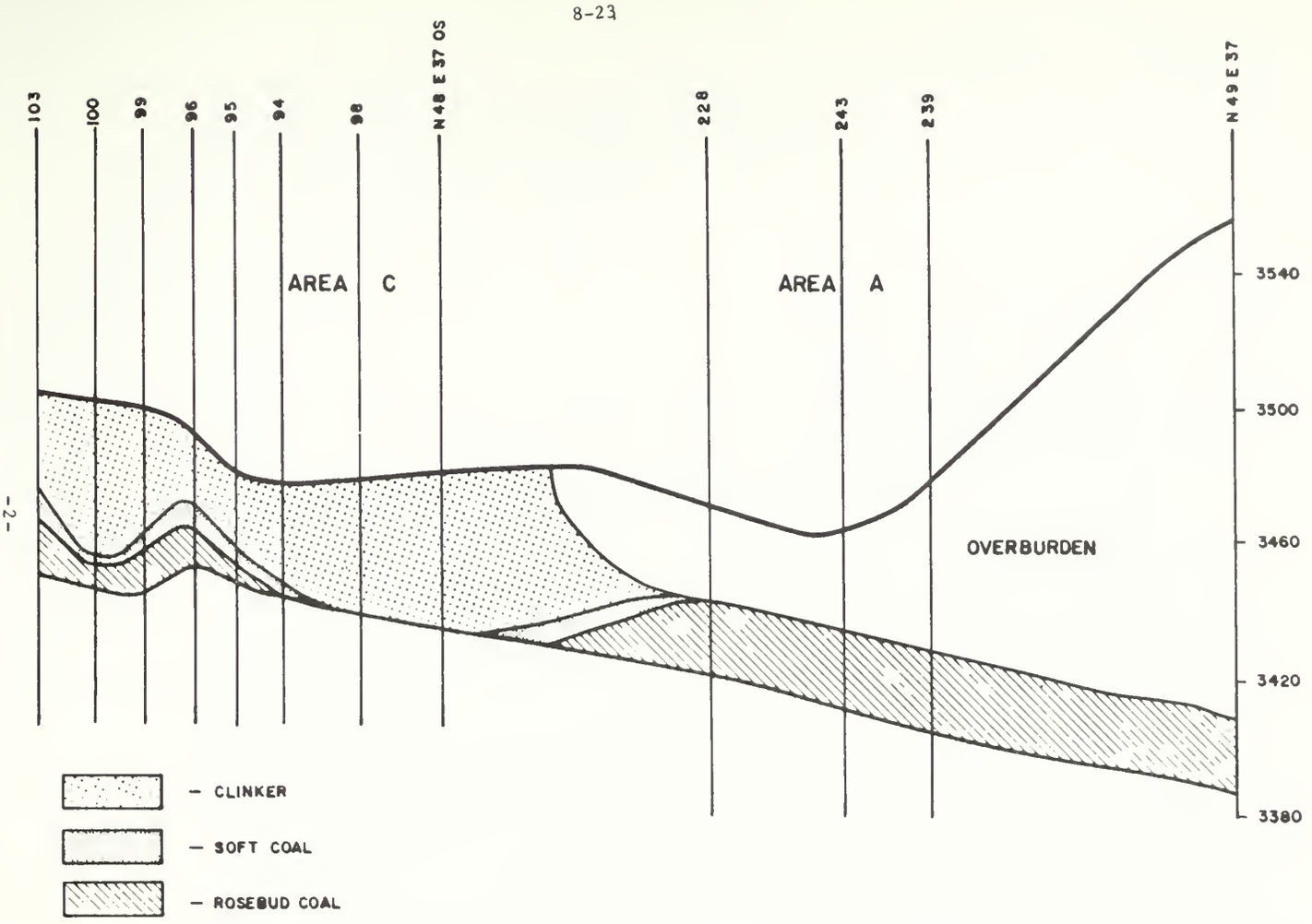
2.2.1.1.4 Rosebud Coal

D

Page: 2 - 17

"The Rosebud coal varies in thickness from zero at the outcrop to approximately 24 feet and has an average thickness of 22 feet."

D--The Rosebud coal seam pinches out to zero where it outcrops or is burned. We have changed the upper limit and average thickness of the Rosebud coal seam as per your comment.



WESTERN ENERGY COMPANY

TITLE: AREAS A & C FIGURE 1
ROSEBUD COAL CROSS SECTION
T. 1 N., R. 40 E, Sec. 1

SCALE Horiz - 1" = 400'
Vert - 1" = 40'
DATE 6/25/82 DRAWN BP/mhr
PROJECT NO C07270

FIGURE 1

-2-

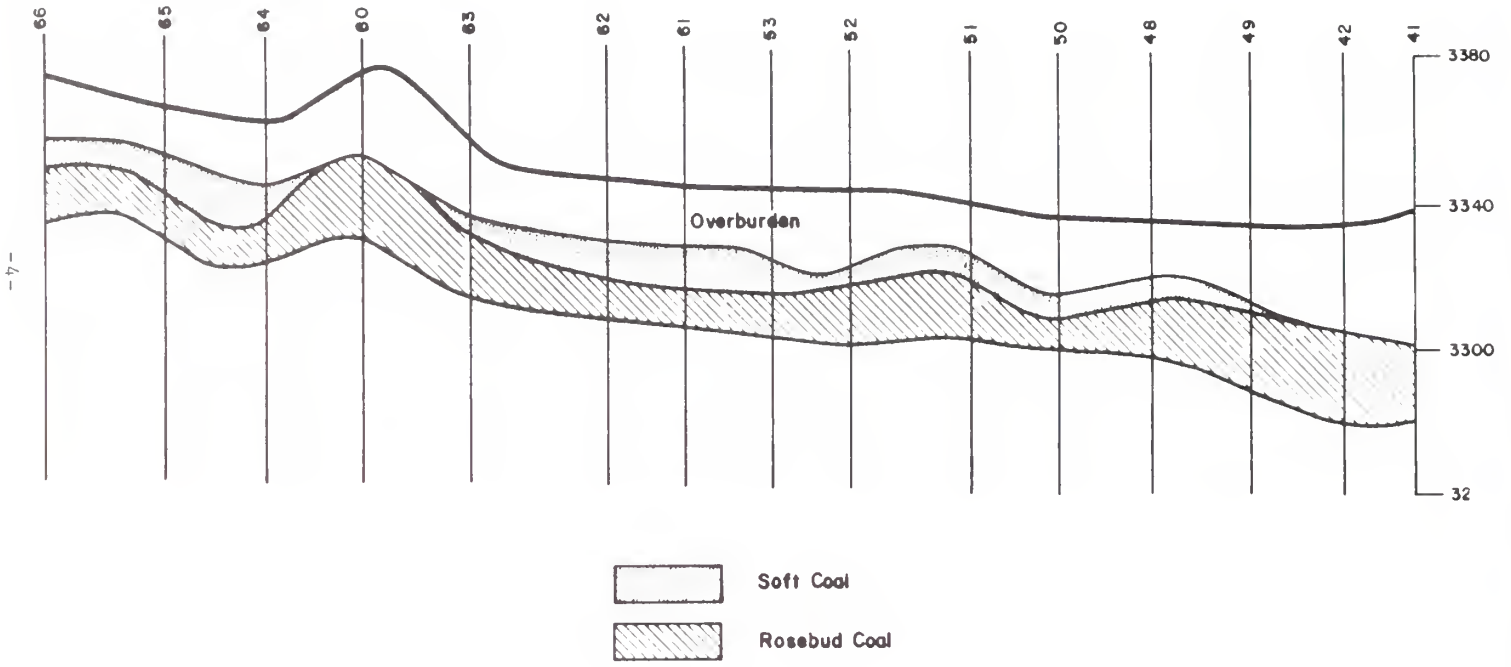
-3-

WESTERN ENERGY COMPANY

TITLE: AREAS A & C FIGURE 2
ROSEBUD COAL CROSS SECTION
LOCATION MAP

SCALE 1" = 400'
DATE 6/28/82 DRAWN PN/mhr
PROJECT NO C07270

FIGURE 2



WESTERN ENERGY COMPANY

TITLE AREA B FIGURE 3
ROSEBUD COAL CROSS SECTION
T. 1 N., R. 41 E., Sec. 7

SCALE Horiz. - 1" = 400'
Vert. - 1" = 40'
DATE 8/25/82 DRAWN BP/mhr
PROJECT NO C07270

FIGURE 3

WESTERN ENERGY COMPANY

TITLE AREA B FIGURE 4
PROJECT ROSEBUD COAL CROSS SECTION
LOCATION MAP

SCALE 1" = 400'
DATE 6/28/82 DRAWN PN/mhr
PROJECT NO C07270

SHEET
FIGURE 4

D The Rosebud coal varies in thickness from 18 feet to 26 feet and has an average thickness of 23 feet.

2.2.1.2 Groundwater Flow

E Page: "A local recharge area appears to be located in Area C. This conclusion is based mainly on geologic and structural evidence."

It is a well known hydrologic principle that the water table will more or less follow the topography (see for example, Fetter, 1980, pp. 77). The water table in Area C reflects discharge areas (Stocker Creek drainage to the north and East Fork Armells Creek drainage to the south) more than "a local recharge area."

E--The text has been changed to reflect your comment. Also note revised potentiometric map of Rosebud and McKay coal seams (Figures 2.2-6 and 2.2-7) which support your statement.

2.2.1.2.1 Nature of Flow Within Water-Bearing Strata

Rosebud Coal Overburden

F Page: "The source of water in the overburden is probably direct infiltration of precipitation, but may also be due to upward leakage from the Rosebud coal."

Western Energy Company's data demonstrates that water levels in the overburden are higher than water levels in the Rosebud coal so "upward leakage from the Rosebud coal" will not occur.

F--Reference to upward leakage of groundwater has been deleted from the text. Except near open mine pits, groundwater generally appears to be moving horizontally or downward, rather than upward.

Rosebud Coal

G Page: "The direction of groundwater flow within the Rosebud coal aquifer is illustrated in Figure 2.2-6."

Contours shown on Figure 2.2-6 do not reflect actual water levels as measured by the Montana Bureau of Mines and Geology, Montana State University or Western Energy Company. The contours possibly result from averaging of data and then applying a process known as "kriging" which is a trend surface analysis technique commonly used in the calibration of computer models.

G--Your statement is correct. This map is a product of modeling and shows general groundwater trends. Because of discrepancies in flow direction, especially near the western margins of the map, it has been replaced by a hand-generated potentiometric map supplied by Western Energy Company. (See revised Figures 2.2-6 and 2.2-8.)

H Page: "Conditions in the Rosebud coal aquifer vary from confined to unconfined, as shown in Figure 2.27, where the bedrock is apparently faulted and fractured. It is not clear whether the faulting has caused groundwater conditions to become unconfined, or if it is because the Rosebud coal seam is almost entirely exposed between the faults. The faults do not appear to cause significant changes in the regional lateral direction of

flow in the Rosebud. The fact that the coal has been offset, but the flow remains unaffected, seems to indicate that vertical hydraulic communication may also be occurring across the fault zone. It is possible that the faulted area provides an excellent conduit for vertical groundwater flow."

H

See comments to page 2-15. Figure 1 with those comments shows that the coal is not offset. Flow is not continuous from Area C to Area A because water in Area C discharges to the north to the Stocker Creek drainage and to the south to the East Fork Armells Creek drainage. As a result, very little (if any) water flows out of the Rosebud coal under Area C into Area A and the Rosebud coal under the western edge of Area A is essentially dry.

H--Your description of flow direction has been added to the text.

McKay Coal

Page: 2 - 23 "Figure 2.2-8 is an illustration of the regional flow in the McKay coal aquifer."

I

Contours shown on Figure 2.2-8 do not reflect actual water levels as measured by the Montana Bureau of Mines and Geology, Montana State University or Western Energy Company. The contours possibly result from averaging of data and then applying a process known as "kriging" which is a trend surface analysis techniques commonly used in the calibration of computer models.

I--See response to your comment G.

2.2.1.2.2. Aquifer Communication

Page: 2 - 27 "As previously mentioned, faulting occurs in both the McKay coal and Rosebud coal west of Colstrip. The facts that 1) the groundwater becomes unconfined near the faulting and that 2) some anomolously high transmissivities exist in bedrock aquifers close to the fault suggest that the faults and fractures might allow intermingling of water between the McKay and the Rosebud coal seams."

J

See comments to pages 2-15 and 2-23.

J--The text has been changed as per your comment.

2.2.1.2.3. Groundwater Recharge - Discharge

Page: 2 - 28 "Figure 2.2-9 depicts recharge and discharge areas in the valley fill material along East Fork Armells Creek. For most of its course above Colstrip, the valley fill receives discharge from underlying and adjacent bedrock and from adjacent spoils. For a short section, the valley fill becomes a losing* system, while it recharges bedrock just upstream from Colstrip. Immediately upstream and downstream of Colstrip, insufficient data exist to establish a relationship; however, it is logical to assume that the valley fill continues to receive recharge from the bedrock in this area."

K

K--The limits of the valley fill around the surge pond included alluvium and other unconsolidated deposits. The surge pond probably has saturated bedrock and unconsolidated deposits as wide as indicated in this figure. The surge pond is believed to be losing a fair amount of water to East Fork Armells Creek depite the slurry and concrete wall under the dam.

K

The MPC power plant surge pond is located along the western flank of the valley downstream from Colstrip. As shown schematically in Figure 2.2-10, the surge pond touches a thin layer of valley fill materials in a minor tributary to East Fork Armells Creek. Valley fill groundwater contours of East Fork Armells Creek show the influence of seepage from the surge pond on the valley fill. This influence is visible as a groundwater mound, causing flow to move perpendicular to the direction of the creek, rather than subparallel to it. It is probable that surge pond leakage contributes to bedrock recharge, because ground water flow in the valley fill is recharging bedrock throughout this reach of East Fork Armells Creek.

The areal extent of alluvium shown on Figure 2.2-9 appears to be much larger than the actual extent of alluvium. Both Figures 2.2-9 and 2.2-10 ignore the slurry wall which was constructed to cut off flow through the alluvium and scoria. The area on Figure 2.2-9 immediately above the Rosebud coal outcrop at approximately N49,000, E54,000 should be shown as "Discharge From Valley Fill System to the Bedrock System, Losing Stream" as can be seen from a comparison of Figures 2.2-4 and 2.2-5.

The area you refer to along East Fork Armells Creek at the western boundary of Area B presently is an area where the alluvium does discharge to the underlying bedrock. But this situation is highly influenced by drawdown of groundwater levels within the Rosebud coal seam due to mining. Whether this area was discharging to underlying bedrock before, or will be after, mining is difficult to determine. Should ground water levels in the Rosebud coal seam exceed the alluvial groundwater levels, the opposite would be true. As such, we have not attempted to change the figure in this area.

2.2.1.3.2. Quality of Water - Bearing Strata

Valley Fill Aquifer

L

Page: 2 - 39 "Table 2 of Appendix B shows data documenting changes in TDS concentrations with time for Wells P-01, P-02, P-03, and P-05. Table 3 of Appendix B compares TDS concentrations of some alluvial wells showing elevated TDS values with alluvial wells in other draingages indicating unaffected TDS levels."

Comparison of Figures 2.2-4 and 2.2-5 shows that water from the alluvium is recharging the spoils in Area A and B near Wells P-01 through P-05. See comments to page 2-52 for a discussion of the possibility of affects to Cow Creek.

L--From reviewing the potentiometric levels in the mine spoils and the Rosebud coal seam in Areas A and B and comparing those to the water levels of the alluvium of East Fork Armells Creek, it appears that mine spoils water from Area A has gradually increased TDS levels in the alluvium of East Fork Armells Creek nearest the mine. Mining in Area B has lowered the alluvial water levels in wells PO-1, PO-2, PO-3, PO-4, and PO-5 on the average 5 to 6 feet, which has allowed Area A spoils water (spoils water levels have been steadily rising since 1975) to enter the alluvium. (See text revision.)

Rosebud Coal

M

Page: 2 - 39 "The high concentrations in the western portion of Area C may be due to a higher clay and shale content in the overburden and to numerous faults, which have produced solution zones, allowing deeper-seated, more mineralized waters to migrate upward into the Rosebud coal aquifer."

Actual water levels demonstrate that the hydraulic gradient is downward except under open pits. See also comments to pages 2 - 15 and 2 - 23.

M--After reviewing the data, we find no area except under active mine pits where the groundwater is moving upward at the Rosebud mine. Reference to such upward leakage has been deleted.

Interburden Aquifer

Page 2 - 40: "Two wells, WI-100 and WI-104 (Figure 2.2-3), located in Area C have TDS concentrations of 1,655 and 2,700 mg/l, respectively, probably typical for interburden aquifer water in Area C."

N

Well WI-100 was a sub-McKay well. Aquifer test data demonstrate that interburden is an aquiclude (or an aquitard at best) rather than a aquifer.

N--Thank you for pointing this out. The text has been changed so that reference is made only to well WI-104.

McKay Coal

Page 2 - 41: "Except where affected by spoils water, TDS concentrations range from about 500 to 2,500 mg/l. The description and concentrations range cited above generally fits the situation in the Rosebud Mine area except for Area E, where wells S-04 (5,725 mg/l TDS), S-08 (3,192 mg/l TDS), and WM-127 (7,455 mg/l TDS) (Figure 2.2-3) indicate elevated average TDS values (see Table 4 of Appendix B). The data for Well S-04 also appears to indicate an increase in TDS with time, indicating an external source of the salinity. The cyclic variation evident in Well S-04 seems to demonstrate that climate has been affecting the recharge to certain wells and the dissolved solids content. That is, wet years produce more recharge and usually lower salt concentrations than dry years. The time when these changes occur depends on the amount of recharge from precipitation, the transmissivity of the aquifer, and the distance from the recharge area. The cyclic effect on TDS can be noted in data from other wells with sufficiently long periods of record. The noted increases and fluctuations may also be due to an external source of contamination of the well."

O

As Western Energy has demonstrated to the Department of State Lands, the poor water quality in Well S-04 cannot be related to the water quality of either the spoils or McKay up-gradient from that well. Water quality for wells up-gradient from S-04 in both the McKay and the spoils are tabulated below.

O--We inadvertently referred to spoils water as the source of elevated TDS levels in the first sentence of this paragraph. We were not sure of the exact nature of the elevated TDS levels for these three wells. For the final, we have edited the text so that the cause (possibly due to both natural and man-caused sources) of the degraded water is left unspecified.

McKay		Spoils	
Well	TDS (mg/l)	Well	TDS (mg/l)
S-03	1348	S-01	2782
S-29	885	S-02	2136
WM-121	305	EPA-3	1157
WM-122	457	EPA-6	4307
WM-123	480	EPA-10	2225
		EPA-12	1096
AVERAGE	695	WS-110	1792
		WS-112	2395
		AVERAGE	2236

O

Water quality data for S-04 shows a decrease in TDS with time since 1979. There is no correlation between water quality and precipitation for S-04, but there is a strong inverse correlation with sampling frequency. See also Western Energy's response to Stipulation 4a in Surface Mining Permit 81003E (Area E).

Water quality in Well WM-127 is a result of drilling additives used to hold the hole open while drilling through scoria. Water quality of Well S-08 is within the range of water quality found in McKay wells upgradient from mining.

Sub-McKay Aquifer

P

Page: 2 - 41 "The majority of waters in the sub-McKay aquifer in the Rosebud Mine area are of the sodium-sulfate type. Water quality data is available for two wells in Area C, WD-101 and WD-102 (Figure 2.2-3)."

Well WI-100 was also a sub-McKay well in Area C.

P--Thank you for pointing out this additional well.

2.2.2.5.1 Streams

Q

Page: 2 - 52 "Water quality samples indicate that TDS, sodium, magnesium, calcium and sulfate are higher in Cow Creek. The elevated concentrations can be attributed to irrigation, natural geologic and hydrologic variations, the town of Colstrip, Montana Power Company generating facilities and to old and existing Western Energy mine spoils."

See also comments to Page 2-23 and Western Energy Company's response to item 2.c (page 3) of the Department of State Lands' third deficiency letter for Application #00100. Potentiometric contours based on actual water levels (as presented in Western Energy Company's Area B, E, and D West applications) demonstrate that there is little possibility that the town of Colstrip or Montana Power Company generating facilities have affected Cow Creek. Water quality data tabulated on the next page suggest that Cow Creek alluvial groundwater quality may be typical of natural water quality from similar sized headwater areas in unmined areas. Upper Cow Creek alluvial groundwater is actually better quality than upper Stocker Creek and if mining has impacted Cow Creek, the impacts are not significant.

Q

Upper Cow Creek		Upper Stocker Creek	
Well	TDS	Well	TDS
559A	2820	WA-166	3943
558A	2770	WA-165	3064
557A	2540	WA-164	2442
WA-132	2685	WA-167	2137
WA-133	3690	WA-168	3244
WA-135	4181	WA-169	4922
WA-142	4776	WA-170	4081
WA-144	5070	WA-110	2290
WA-145	4805	WA-111	2807
WA-134	2447	PW-107	6640
WA-138	DRY	PW-53	1589
AVERAGE	3578	AVERAGE	3716

Q--This section has been reworded. There is a groundwater mound of poor-quality water in the interburden and probably the McKay coal seam under the existing industrial ponds located adjacent to the power plant and the city of Colstrip. (See additional text, Chapter III, Section 3.2.3.) Also, see response V to your comment.

2.2.3.8 Hydrologic Budget Analysis

R

Inflow

Page: "Discharge from the Rosebud Aquifer 130 acre-feet/year"
2 - 61

In order to "calibrate the model", ERTEC used transmissivity values much higher than what has been measured in the field. These values resulted in calculated flows which are higher than what has been observed.

R--We agree, but we did not change the number for lack of better data.

S

Page:
2 - 62 "3. The actual uptake by plants is less than that calculated."

Dollhopf, et al (1982, p. 55) reported an evapotranspiration rate of 34.7 cm/yr measured at Colstrip (Pit 6).

S--Your figure of 34.7 cm/yr is much less than reported (25.2 inches per year) on page 2-61 ¶5 of the draft EIS. Your number has been added to the quoted statement.

3.2 Hydrology

3.2.1.1.1. Groundwater Flow

Recharge/Discharge Relationships:

T

Page: "Based upon the hydrologic model, a portion of Area C is believed to be
3 - 10 an area of groundwater recharge (Section 2.2)."

See comments to page 2-19.

T--This paragraph has been deleted.

Groundwater/Surface Water Relationships

U

Page: "The discharges in Table 3.2-3 were computed by summing groundwater discharges (per computer node) along each drainage, as calculated by the 3 - 15 flow model."

See comments to page 2-61.

3.2.1.1.2 Groundwater Quality

Valley Fill

V

Page: "Alluvial groundwater quality of Cow Creek (Table 3.2-4) and the South Fork of Cow Creek will be further affected by continued mining at the 3 - 18 Rosebud Mine. Mining is suspected of increasing TDS levels in the alluvium of ephemeral tributaries to these two drainages."

See comments to page 2-52.

3.2.1.1.3 Water Use

W

Page: "From the data, excluding Well 55 which seems to be contaminated, the 3 - 21 average TDS concentration in the sub-McKay is 2,183 mg/l."

Where is "Well 55" and how is it "contaminated"?

3.2.2.2.6 Water Quality

X

Page: "The rate of seepage from this pond could be as high as 90 gpm which if 3 - 51 left unchecked would significantly increase TDS levels of both the Cow Creek alluvium (5 fold) and of the surface waters of Cow Creek. To control this seepage, Montana Power Company has proposed a clay (bentonite) barrier built to bedrock encircling the pond. In addition, numerous groundwater withdrawal wells will be placed around the perimeter to capture and recycle seepage water that is not retained by the bentonite barrier. As a result, maximum net seepage losses of the pond at the property boundary would be a maxiumum of 20 gpm. This amount of seepage if entered directly into the alluvium of Cow Creek would still raise the TDS levels from around 2,700 mg/l to about 6,700 mg/l."

Western Energy Company has no data on which to base an assessment of the accuracy of the figures of 90 gpm or 20 gpm and does not know the source of these figures. Calculations of groundwater flow through bedrock and alluvium from the proposed pond toward Cow Creek suggest that the above figures are too high. There will be no flow from the pond through the

U--Text has been added to reflect your comment.

V--The potentiometric map of the Rosebud coal seam includes mine spoils in Area E. (See Figure 2.2-6.) It is difficult to actually determine where the spoil water is going, and several different interpretations of these potentiometric contours is possible. However, using the contours in this figure, there appears to be a convergence of spoils water moving toward South Fork Cow Creek. The potentiometric contours of the underlying McKay coal seam clearly show a strong component of flow toward Cow Creek. Although there are not enough wells in the Rosebud-McKay interburden to allow one to draw an accurate potentiometric map, we believe that the potentiometric contours are probably somewhere in between those of the Rosebud coal seam and the McKay coal seam. As such, some of the mine spoils water is probably leaking into the interburden and moving toward Cow Creek and South Fork Cow Creek. (Also, see Chapter III, Hydrology, Cumulative Hydrologic Impacts for a discussion of industrial pond seepage toward Cow Creek.)

Although we cannot prove conclusively, because of lack of baseline data, that alluvial groundwater quality in the headwaters of Cow Creek has been degraded slightly, we still believe changes have occurred. Ponds along the eastern edge of Area E in old mine spoils are in the headwaters of the tributary ephemeral creeks to Cow Creek. They have TDS levels above 4,000 mg/l (MDSL, 1981, p. II-15). These ponds seep into the alluvium of the Cow Creek tributaries, and, downstream, the TDS levels have probably increased above baseline conditions.

Western Energy does not have enough shallow wells between the mine spoils (Area E and Pit 6) and these tributary creeks to determine the extent of suspected bedrock groundwater movement toward these tributaries.

W--Well "55" was a misprint. The well referred to is well 5-S. The text has been corrected.

X

alluvium in the tributaries containing Montana Power Company Wells 561A and 562A because these wells are dry. The calculated flow through the alluvium at Well 553A is only 0.0035 gpm, and Well WA-133 below 553A was dry for several months during 1982. The calculated flow through the bedrock aquifers between the pond site and Cow Creek is 4.8 gpm. The slurry wall will serve to further limit the amount of pond water which might reach Cow Creek.

X--The 90 gpm seepage rate and 20 gpm flow at the property boundary was supplied by Bechtel (Montana Power Company's consultant). See additional text on the fly ash pond, Chapter III, Hydrology, Cumulative Hydrologic Impacts.

3.9 SOCIOLOGY and ECONOMICS

3.9.4 Public Finance Impacts

Y

Page: 3 -103 "Table 75 (Appendix E) lists severence tax and royalty payments for various years of the cumulative scenario."

Table 75 could not be found in Appendix E or elsewhere in the document.

Y--Table 75 has been added to Appendix E.

4.0 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY OF THE LANDS AFFECTED BY MINING

Z

Page: 4 - 1 "The headwaters of the ephemeral creeks located east of the mine (Spring, Pony, Cow, South Fork Cow) would eventually receive groundwater with slightly higher salt levels than premine groundwater. Small localized areas along the upper reaches of these creeks would undergo shallow alluvial groundwater changes that would slightly reduce the vegetative productivity of these areas."

Groundwater flow in Area D is to the south, so Spring Creek will not receive spoil water. Alluvium of Pony Creek and main stem of Cow Creek is discontinuous so impacts to alluvial groundwater of Pony Creek and Cow Creek from Area D will be negligible or undetectable (see also comments to page 2-52).

Z--Groundwater flow through Area D may not be entirely to the south. Some small amount of Rosebud coal seam and Rosebud overburden groundwater flow may be to the north, toward Spring Creek. WECO does not have enough wells along the northern edge of Area D to determine whether a groundwater divide exists or the potentiometric contour gradient merely flattens. (See Chapter III, Hydrology, Cumulative Hydrologic Impacts.) DSL and OSM have seen no evidence that the alluvium in the main stem of Cow Creek is discontinuous, which WECO mentions. The alluvium along Pony Creek is almost nonexistent through Area D, but it does pick up to the east (downstream).

5.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

AA

Page: 5 - 1 "Groundwater quality within and down-gradient of the mine area would be irreversibly degraded (See Long-Term Uses Versus Short-Term Productivity)."

This statement is conjecture and should be stated as such (see also comments to page 2-52).

AA--DSL and OSM believe this statement to be factual, not conjectural. (See Chapter II and Chapter III, Hydrology, Groundwater.)

Letter 10

United States Department of the Interior
NATIONAL PARK SERVICE
ROCKY MOUNTAIN REGIONAL OFFICE
655 Parfet Street
P.O. Box 25287
Denver, Colorado 80225

IN REPLY REFER TO:
L7619 (RMR-PC)

MAY 1 1 1983

Mr. Kit Walther
EIS Team Leader
Department of State Lands
Capitol Station
Helena, Montana 59620

Dear Mr. Walther:

We have reviewed the environmental assessment for Western Energy Company's Comprehensive Plan for the Rosebud Mine and have determined that the proposed plan would not have impacts or potential impacts on any present, proposed or potential unit of the National Park System or any other areas or features where the National Park Service has program responsibilities.

Sincerely,

for Richard A. Strait
Associate Regional Director
Planning and Resource Preservation

Thank you for your comments.

Rt. 1
Forsyth, MT
59327
5/9/83

Letter 11

Dept. of State Lands
EIS Team
Capitol Station
Helena, MT. 59620

MAY 1 2 1983

Sirs:

A I hope it does not prove to be an exercise in futility to comment on this draft EIS on the Rosebud Mine at Colstrip. Experience has shown that these documents too often skirt out around the central problems with a swarm of details, while passing mention or lip service are given to the real problems. Meanwhile, politics and industry seem to charge along unmindful of many rights and needs of others. Hopefully there is no conscious decision that the country folk produce too much food and they can be scrapped along with the surplus groceries. However, it is all too common for EIS's to calmly enumerate things that will lead to the elimination of useful agricultural land and/or interests. Unfortunately, this draft EIS fits the same old pattern in many ways, but there are parts here and there that at least address some of the problems the country folks see.

The bullet should have been bitten long ago on some of the developing water problems at Colstrip. Now that bullet has grown into a bomb in places and is still growing. It is not too late yet for mitigating measures.

The following questions and comments are largely on the sections dealing with water.

B Pg. 2-15, paragraph 3: Did the aquifer tests check for quality? If so, were any of them done far enough down the creek so there is a possibility of picking up pollution radiating out from the fly ash pond? Are there any such monitoring tests done there?

C 2-28, par. 5: "...surge pond touches a thin layer of(porous) valley fill material." Do I understand correctly that the surge pond dam was set on top of this fill rather than blocking it? I assume the water moves laterally in the McKay coal under the pond while it also moves downgradient where the porous soil did not get the benefit of the concrete that was added. Is this correct?

D 2-28, par. 6: By subtraction I find that the seepage from the fly ash pond is 29 acre-feet/year. Table 2.2-2 says estimated seepage is 21 acre-feet/yesr. Where is the discrepancy? By what method was this seepage figure arrived at in the first place?

E 2-37: Good stock water has less than 2500 mg/l TDS; unfit has more than 4500 mg/l. Some dairy cow would apparently drink it at 7150 mg/l and beef cow(s) at 10,100 mg/l. The type and flavor of the dissolved solids apparently werenot taken into consideration, nor were the tastes and tolerances of individual cows. Some "experts" use a much lower upper limit for cattle. The EIS says stock must drink more water as the salts increase. Experience says they will drink less because they like it less.

F 2-40, par. 4: The interburden aquifer had TDS concentrations of 8000 to 9000 mg/l. Pre-mining levels were 500 to 3500 mg/l. What are the allowable limits of aquifer degradation?

G 2-41, par. 4: Well 5-S demonstrates that there can be downward movement of toxic water through the interburden, through the McKay coal and on into the sub-McKay. What are the allowable limits of aquifer degradation?

H 2-67, par. 3: The mild weather statistics sound like a Colstrip chamber of commerce was trying to attract tourists. Perhaps their outdoor heating makes the figures true.

A--Your comment is noted. Thank you.

B--Aquifer tests are for flow characteristics only. There are water quality monitoring wells installed around the existing fly ash pond, including two recently completed monitoring wells downstream in the alluvium of East Fork of Armells Creek. (See fig. 3.2-13.) Water quality data for some wells are available for 1½ to 2 years before the fly ash pond was filled.

C--You are correct. See Section 3.2.3.1.1.2, Deeper Aquifers for a discussion of your comment.

D--The 21 acre-feet per year is the proper estimate and was based on tests of the underlying material, as explained in the reference for table 2.2-2. We are uncertain as to how you derived the value of 29 acre-feet per year.

E--Additional parameters by which livestock water can be gauged have been added to the text in Chapter II, Hydrology, Section 2.2.1.3.1. In addition, the text describing livestock salt tolerance has been revised. Numerous researchers have reported that water uptake increases as salinity increases if no other water source is available (National Academy of Sciences, 1974, p. 41).

F--The new Montana Ground Water Quality Standards protect existing and potential uses of groundwater. Because the quantity of bedrock groundwater around the ponds is so small as to preclude its potential development, the primary concern appears to be how the contaminated groundwater would affect surface-water and alluvial groundwater quality of Cow Creek and East Fork Armells Creek. (See Cumulative Hydrologic Impacts.)

G--Well 5-S is a Rosebud-McKay interburden well. No sub-McKay wells exist beneath the industrial ponds in the direction that contaminated groundwater would go, so it is impossible to determine the extent of downward leakage of industrial pond water.

H--Your comment is noted. Thank you.

I 3-5,6: Isn't it possible that fracturing from blasting could cause natural aquifers to alter their normal flow direction, either horizontally or vertically as happens in other places? Were monitoring wells drilled to below the blasting level to check possible downward changes in water quality or amount?

J 3-6, last par.: "...future subsidence...under four feet." May I point out that on pg. 3-45, par. 2 it says, "With time, replaced materials would settle and approach a density similar to that which existed prior to mining." If the "swell factor" is only 20%, as stated by Western Energy, then this would mean 20 feet of settling, with time, on a 100 foot pit. How do you match your two statements together?

K 3-8, Table 3.2-1: Is the fly ash pond considered when it says there is "no expected change" in the groundwater quality of the Stocker Cr. drainage? If so, whereare the monitoring wells located that prove this toxic material is not radiating out in several directions?

Is the new fly ash pond considered in the Cow Cr. statistics? If not, what should the table read with the toxic seepage added in?

L 3-10: To say the fly ash pond leakage is insignificant must mean there are statistics available on this leakage. Exactly how were these figures compiled? Do tests show any leakage perpendicular to the flow line of the drainage?

3-15, par. 5: Are industry-related waterlogging/salinization problems on East Fork Armells Cr. and Cow Cr. accepted as constants that are normal and insignificant, even though ongoing?

M 3-16, Table 3.2-3: It would be interesting--and fair--to compile this same table using only minimum amounts, and then compile another table using only the maximum figures that might be extrapolated from this work and guesswork on groundwater. The probability of gross error is very high for the present date, let alone guessing at 135 years from now. Minimum and maximum figures might extablish a range that could hopefully cut down some of the magnitude of inaccuracy that today's errors would cause.

N 3-17, par. 3 says that spoils groundwater is 1½ to 2½ times more saline than pre-mining groundwater. This is hardly an encouraging statement for people who are acquainted with the realities of poor water on a livestock operation.

O 3-17, par. 5 says the higher TDS will still be okay for stock. However, reduced intake of water because of bad taste has a corresponding reduction in weight gain.

P 3-18, par 1 informs us that increased water in Armells Cr. would dilute the TDS which would then not significantly affect agricultural uses of the groundwater. That's nice, but the climate is wrong to grow rice in the waterlogged places that used to produce winter feed.

Q 3-18, par. 2: I am still trying to decide whether the fly ash pond leakage into the Stocker Cr. drainage has gone into remission or omission. Which is it?

R 3-18, par. 4: Which distant, large city did the author of this paragraph come from?

S 3-18, par. 5: Who would pay for these new wells?

T 3-21, last par. is typical of inadequate data upon which generalities are too commonly based.

U 3-22: Turn around 180° and take another shot at the page on replacing lost wells--you surely couldn't miss the mark any further than this did.

I--No instances of blasting affecting aquifers are known to be documented. Several studies (see p. 3-5, 6 of draft) have shown little or no effect from blasting. If the commentor has documentation, DSL and OSM would appreciate receiving a copy. More than 36 monitoring wells have been completed into the Rosebud-McKay interburden, the McKay coal seam, and the sub-McKay strata within and around the Rosebud Mine. No conclusive evidence of downward leakage of mine spoils water has yet been gathered, but since the natural trend in this area is for the groundwater to move downward, future changes in sub-Rosebud water quality can be expected.

J--The statement that the spoil material would approach pre-mining density is overly optimistic. The 4-foot subsidence is an estimate based on experience. The text has been changed.

K--Table 3.2-1 covers only the mining and related impacts and not the impacts from the generating plants. Text has been added to clarify the water quality impacts from the existing and proposed fly ash ponds. (See Chapter III Section 3.2.)

L--The statement refers to groundwater quantity and not to quality. The amount of seepage from the existing fly ash pond is so small that it does not appreciably change the quantity of water in the system. Analysis of quality changes has been added. See response to your comment K. Flow does radiate outward from the pond for some unknown short distance until it finally merges with the local natural flow system. Thus, some of the flow is perpendicular to the natural drainage for some length.

We have clarified predevelopment, existing, and future changes in flow and quality in Chapter III, Section 3.2.3 in response to your comment.

M--Estimates of maximum and minimum flow rates to be used in the model would be no more accurate, and could be less accurate, than the rates used. The rates used were developed using aquifer test properties and are felt to be reasonable. Inaccuracies in model predictions would not be reduced by comparing two computations that are no more accurate than the single one used.

N--Your comment is noted. Thank you.

O--If groundwater wells were developed in mine spoils at the Rosebud Mine, the increase in TDS levels probably would not have an adverse effect on livestock, inasmuch as TDS levels ranging from 3,000 to 5,000 mg/l would be well below the 6,000 to 7,000 mg/l threshold where adverse affects may begin to occur. (Also see response to your comment E.)

P--Your comment is noted. (See Section 3.2.3, Chapter III, Hydrology.)

Q--See added text discussing the existing fly ash pond in Chapter III, Section 3.2.3.

R--It is not possible to be more specific than the statement in the text.

S--The company would be required by both Federal and State regulations to furnish an alternate supply of water for any wells that are impaired or diminished. This could include drilling of new wells or deepening of old ones. Also, see response to comment V.

T--The average and range of values of sub-McKay groundwater quality (19 wells) are similar to those in the Rosebud coal seam. The same is true when comparing the sub-McKay to springs.

U--We have revised the text as per your comment. (See revised text, Chapter III, Section 3.2.1.1.3.)

V--Section 82-4-253 (3) Montana Strip and Underground Mine Reclamation Act (title 82, chapter 4, part 2, MCA) gives the authority to the Department to order a mine operator to replace a diminished water supply with like quantity, quality, and duration, if the loss is caused by the surface coal mining operation. This section also requires the company to immediately replace the loss with a temporary supply. The Department may suspend the operator's permit for failure to replace the water. There is no limit of distance, only if the disruption is caused by mining. The additional operating and maintenace costs associated with a new or deeper well would not necessarily have to be borne by the landowner. Section 82-4-253 provides the landowner the right to sue for damages. The cost for such legal actions may be borne by either the landowner, the company, or both, depending on the outcome and nature of the suit. Note that this law applies to potential damages associated with coal mines and not other sources.

V 3-22, last par.: Who would make the company put in a well? How far from the edge of the pit does this extend? Is there to be a written guarantee the water would be replaced? Why should offsite landowners pay any additional maintenance costs because his industrial neighbor used poor (if common) groundwater reclamation techniques? Who pays for the probable--and endless--legal wrangling? Who waters the stock in the interim? Who pays for watering them?

W 3-32, par. 2: Have patience. We are going to "lessen the severity" of waterlogging in E.F. Armells Cr. in 34 years, and it "is assumed" that it will return to normal sometime after 135 years. I can hardly wait.

X 3-32, par. 3 says: If equals 1% (maybe). That's interesting arithmetic. It goes on to say none of it is significant. Hmmm.

Y 3-32, par. 4: The "non-mining" mine ponds, etc. will continue to affect the amount of flow in the system. Are you suggesting we watch this problem, or get busy with mitigation measures?

Z 3-32, par. starting on bottom of page talks about water that is marginally suited for stockwater. Their theory is that higher salt levels would increase the water consumption of livestock. It sounds reasonable, but the problem will be to even get them to drink a normal amount. Some individual animals have a much greater tolerance for poor water than others do. Some individuals fall off in flesh because they won't drink enough of the poor quality water. This is especially true of younger animals. Occasionallyan individual animal will not drink enough to even remain healthy. They need plenty of water to digest dry feed.

AA 3-33, par. 3talks about TDS being high for thousands of years in spoils. This is why I have long advocated narrow gravel conduits across spoils to move aquifer water across with minimal opportunity to leach contaminants out of the spoils.

BB 3-33, par. 6: Saline seep continually fed by groundwater has to spread on down the creek bottoms. It says the "overall agricultural visbility of the Colstrip region would not be affected." This glib statement is much easier said by the sacrificer than by the sacrificee. But, if kept limited, it is largely true. Damaging the heart of only a few ranch units shouldn't hurt many of the other ranches much. Such damage violates the intent of both man's and God's law, but somehow we talk ourselves into believing it is necessary in order to help overfill the existing electricity glut. Aren't our values distorted when we pay for adding to such a glut with irreplacable land?

CC 3-33,34: Whether it takes 100 years or 10 years for degraded water to reach Cow Cr., the long-term violence done to the land is not reasonable to condone.

DD 3-34: The first paragraphs are a description of how saline seep can be started on Cow Cr. (Most people seem to think it is rational to try to stop saline seep.) A huge fly ash corral with no real bottom should accelerate the degradation. Since DSL has a part in permitting some of this, do you have any specific trigger point beyond which further degradation will not be allowed? Do you have in mind how to fund the eventual necessity of trying to stop and/or clean up the degradation you have had a part in permitting in the first place?

EE 3-34, last par. talks about marginally subirrigated vegetation that will be lost on Stocker Cr. Are you comfortable with talking about this and ignoring vegetation on the same creek that may be marginally dead from spreading fly ash malignancy?

FF 3-35, par. 1 strikes me as a sweep-it-under-the-rug statement deserving of the following comment: Neither will the economic pattern of the U.S. change because Colstrip

W--Your comment is noted. Thank you.

X--The "if" means it might not happen.

Y--There is no such suggestion implied in the statement. Only that the nonmining effects can be expected to continue in the future. (See ection 3.2.4 for discussion of waterlogging mitigation measures.)

Z--In response to your comment see revised text, Chapter II, Section 2.2.1.3.1 for discussion of suitability of water for livestock.

AA--A French drain type system would move the water through more rapidly for short time, until the backwater from the natural aquifer downgradient would cause the water to flow slower and slower. Eventually, the spoils would become filled to some groundwater elevation in equilibrium with both upgradient and downgradient water levels. As such, the spoils would eventually be saturated to about the same levels with or without a French drain.

BB--Your comment is noted. Thank you.

CC--Your comment is noted. Thank you.

DD--DSL is not involved with the permitting the proposed fly ash pond. Permitting authorities are with the Board of Natural Resources and Conservation, the Department of Natural Resources and Conservation, and the Department of Health and Environmental Sciences. The "trigger point," beyond which no further degradation is allowed is established by the Montana Groundwater Standards (ARM 16.20.1001 through 16-1012.1).

EE--Mining in Area C would only appreciably affect the headwater tributaries of Stocker Creek. We believe that only a small amount of degraded sub-McKay water below the fly ash ponds flows to Stocker Creek. The large flows (50 to 250 gpm) in the Stocker Creek alluvium would sufficiently dilute those inputs to insignificant levels.

FF industry tripled, or because it caught chicken pox and died. So what if a few heads roll here and there as long as only an unimportant percentage of businesses of the electorate are killed.

GG 3-35, par. 2: This must be of esoteric academic interest since the previous paragraph deletes most of the non-persons who would have cared.

HH 3-40, 41: The paragraph starting on the bottom of page 3-40 clearly admits that water problems not really dealt with in this draft EIS overshadow the problems being dealt with. DSL has said that they would require a comprehensive hydrology study before issuing more permits. Does this mean that mining permits will be held up until a comprehensive hydrology study is completed?

Gnats and other trivia are strained out while camels are swallowed whole, so it might be fitting to waste a little paper commenting on the seepage out of the swimming pool.

II 3-45, par. 2: Have you noticed the contradictory statements in this paragraph? Which of the opinions do you agree with?

JJ 3-45, par. 3: It is good to read some facts here about a real problem. However, your dream about having all piping problems mitigated at bond release may turn into a nightmare if the settling problems I commented on on pg. 3-6, last par. continue to subside until normal density is reached.

KK 3-46, par. 4: Being careful of semantics does not change the relationship between strip mines and power plants and surge ponds and sewage lagoons and fly ash ponds which total up to very significant hydrological problems. Will this be lost in departmental and agency shuffling, or are there plans to deal with the total impact?

LL 3-48, par. 6: I appreciate the mentioning of some real problems in this paragraph. They are problems that must be dealt with. What mitigating measures do you recommend?

MM 3-50: The list of water amounts and TDS on this page have a great deal more significance to the viability of the land than does so much of the information on previous pages. Work needs to be done on these figures because some of them are estimates that can and should be verified or changed to more accurate figures. (Long use of estimated figures tends to legitimatize those figures, whether or not they are accurate.)

NN It is a glaring omission that the fly ash pond on the Armells Cr. drainage is not included in this listing. It does not seem reasonable to exclude a toxic waste dump's seepage from a list of interrelated hydrologic data in the vicinity of the mining/generating complex. Depending on which part of the draft EIS you get the figures from, this fly ash pond leaks either 21 or 29 acre-feet/yr. Considering the size of the pond and the poor sealing material used on part of that porous soil, either figure is probably far too low. Notice that some of the much smaller power plant ponds (supposedly sealed) are estimated to leak very roughly half as much as the amount(s) given for the fly ash pond. In addition it must be borne in mind that the toxic recharge of subsurface water from the fly ash pond is much larger than just the pond itself. The pond's evaporation sprinklers saturate a large area near the pond. The sprinkled area can in no way claim any sealing material was applied previous to being saturated with fly ash water.

OO Incidentally, the arithmetic immediately under the list needs to be checked.

PP 3-51, par. 2 again makes clear the need to include all the hydrologic data in a comprehensive inventory and analysis of impacts that have resulted from digging up some coal in the Colstrip vicinity.

QQ 3-51: Curiously, the existing fly ash pond is largely left out of this draft EIS while the one being built is dealt with to some degree. Extrapolating figures from

FF--This section deals with mining impacts only and means that no single landowner will be significantly impacted by the mining. (See Chapter III, Cumulative Hydrologic Impacts, Section 3.2.3.)

GG--Your comment is noted.

HH--The agencies feel the final environmental impact study adequately addresses the cumulative hydrologic impacts of all anticipated mining as required by Federal and State mining regulations for the agencies to make permitting decisions for the Rosebud Mine.

II--DSL and OSM see no conflict in this paragraph. A conflict between the first sentence and the last of the next paragraph regarding the long-term significance of piping has been corrected.

JJ--Experience has shown that the piping problems and most of the subsidence occurs within the first 5 years.

KK--The various agencies involved are coordinating their efforts to the extent possible and practicable.

LL--Please see Chapter III, Section 3.2.4 for a discussion of waterlogging mitigation measures.

MM-- The amount of seepage and discharge from these sources are estimates from published reports. Based upon our knowledge of the pond characteristics, we believe these estimates to be reasonable.

NN--Text and table have been changed to include the fly ash pond.

OO--The numbers have been corrected.

PP--Text has been added to Chapter III, Section 3.2.3.

this somewhat-sealed (according to current plans) pond under construction and using them on the barely-sealed existing pond and polluted area gives us some idea of the magnitude and importance of dealing carefully andthoroughly with both the old and new ponds. (Most ponds are called a lake when they cover well over a half section, as is the plan for the new one.)

QQ

If the seepage from the new pond is actually 20 gpm, that adds up to about 10½ million gallons/yr. of very undesirable water. (The blanket term, TDS, is convenient, but not specific enough to point out the toxicity of some of the solids dissolved in that water. This focuses on the need to have maximum allowable limits on individual solids that travel into the aquifers, rather than lumping them all together. For example, sodium and mercury and boron compounds can all be lumped together as TDS, yet there is a considerable difference in the stress they cause plants and/or animals.) Millions of gallons of water annually surfacing and evaporating as it travels down Cow Cr. drainage has no choice but to leave its heavy salt load on the surface of the ground. Using the estimated TDS of 35,000 mg/l given for power plant ponds and the computed estimate of 20 gpm seepage, my arithmetic says there would be over 1500 tons/yr. of salts taken down the Cow Cr. drainage from the fly ash pond alone. The salts leaching in from the spoils water would be in addition to the 1500 tons/yr. from the ash pond. (The magnitude of deviation from accuracy could be considerable on the 1500 ton figure. Like so many numbers in the draft EIS, it is basically derived from a combination of estimates and supposition.)

RR

As I recall, the Romans salted the fields of the Carthegenians as a punitive measure and as a military strategy to limit their strength by limiting their food. Perhaps I've missed something that is going on in my community. Do you suggest any compensation for the paralysis caused by salted meadows? I do not expect my neighbors to retaliate with warfare the way the Carthegenians did. Neither do I expect them to accept this kind of treatment with a resigned shrug.

SS

A similar problem with salinity is to be expected in the drainage below the fly ash pond on the Armells Cr. drainage. This draft EIS is supposed to be, as the title implies, a statement about impacts on the environment. Divisions of labor among agencies and semantic gymnastics about what is or is not related to mining do not make an iota of difference in the impacts the coal industry has on the environment in the Colstrip area. I'm afraid that a document entitled "Comprehensive EIS" is likely to be treated as if a comprehensive study had been done, even though it does not deal with some of the major impacts. The net effect of this is likely to be that these major impacts will be swept under the rug where they can fester and grow increasingly unmanageable.

TT

It seems to me to be irresponsible to condone ongoing environmental malignancies with silence, meanwhile losing responsibility for them in the gap between agencies. People in the agencies concerned should be able to share information on such matters in order to close the gaps. Do you plan to close those gaps and make this EIS comprehensive? I encourage you to do so.

UU

DSL has said they will issue no more mining permits until a comprehensive hydrology study is done. If you do not do that with this EIS, when will that study be done?

VV

Some of my reactions to statements in this DEIS may sound like overreactions to my city cousins. Some things it calls "insignificant" come closer to looking insurmountable to the folks faced with handling them. I hope I have been able to communicate some of the country perspective in these pages.

Sincerely,

Nick Golder

Nick Golder

QQ--See response to comment PP.

RR--See response to comment PP.

SS--The companies, Montana Power and Western Energy, are responsible for damages caused by their operations. Also, see your response V and DD.

TT--The final Comprehensive Environmental Impact Study deals with the major issues associated with the Rosebud Mine to the extent allowed by the available data.

UU--The draft and final Comprehensive Environmental Impact Study have been distributed to both Federal and State agencies for review and comment.

VV--See response to comment TT.

NORTHERN PLAINS RESOURCE COUNCIL

Letter 12

Field Office
Box 888
Helena, MT 59624
(406) 443-4965

Main Office
419 Stapleton Building
Billings, MT 59101
(406) 248-1154

Field Office
Box 886
Glendive, MT 59330
(406) 365-2525

RECEIVED
MAY 11 1983
STATE LANDS

Dennis Hemmer
Commissioner
Montana Department of
State Lands
1625 Eleventh Ave.
Helena, Montana 59601

May 9, 1983

RE: Comments on Draft Comprehensive Environmental Impact Statement, Western Energy Company's Rosebud Mine Colstrip.

Dear Commissioner Hemmer

We'd like to thank you for the opportunity to briefly comment on the long awaited Comprehensive EIS for the Rosebud mine.

A Before commenting on specifics in the DEIS, we would like to stress that we don't feel that this analysis is a comprehensive analysis as required by law.

B We feel, and would request the State to respond, that 82-4-222(1) directs the state to "collect sufficient data for the mine site and surrounding areas, so that cumulative impacts....." further, 82-4-227(3)(a) does not allow the Department to approve an application until "the proposed operation thereof has been designed to prevent material damage to the hydrologic balance outside the permit area"

This document dismisses the hydrologic impacts from the present fly ash pond as insignificant(though admitting that it's probably seeping directly towards Cow Creek). It further states that the stress from the proposed fly ash pond has not been factored into the groundwater assessment. How can an adequate baseline to determine material damage be developed or how can sufficient data be collected if these major influences are not included in the analysis? We submit that to comply with the intent of the law as it relates to the necessity for the State to prepare a cumulative hydrologic assessment prior to issuing further strip mine permits at the Rosebud mine, that all mining and industrial activities must be analyzed.

C

D p 1-10 Reclamation: does this discussion include the segments of Area E that is and will be used for industrial facilities including ponds?

A--Your comment has been noted. Thank you.

B--The reference to the fly ash ponds was taken partially out of context. The fly ash ponds were not included in the groundwater flow model because their flow rates were insignificant when compared to the regional system (p. 3-10). The quality impacts of the ponds are discussed in the reorganized section 3.2.3.

C--Your comment has been noted. Thank you.

D--Reclamation of the industrial ponds is briefly discussed in Section 3.2.4, Chapter III. Groundwater impacts are discussed more fully in Section 3.2.3, Chapter III.

L--The seepage from the ponds was not considered in the flow model. See response to comment C of your letter. See Section 3.2.3 of text for discussion on both ground- and surface-water influences of all industrial ponds.

M--The predicted total suspended particulate (TSP) concentrations shown in Figures 3.4-1 and 3.4-2 were based on controlled particulate emissions. That is, the emission rates were corrected to incorporate dust control. Therefore, the air quality effects are, in essence, an analysis of the minewide dust suppression plan. The specific control efficiency of each dust suppression measure is described in the Technical Support Document and Western Energy Company's Air Quality Permits 1570 (Area C) and 1483 (Areas A, B, and E).

N--A wider range of seepage rates have been used relative to seepage from the proposed fly ash pond. Seepage rates from existing ponds have also been given a wider range in the salt loading analysis. (See Section 3.2.3.)

O--The statement of insignificance pertained to flow only. The water quality impact of the existing fly ash pond has been added in the Cumulative Hydrologic Impacts (Section 3.2.3).

P--The 5- to 25-percent increase is for the headwaters of Cow Creek, whereas the no noticeable change is for midstream on down. Only old mine spoils in Area E presently affect Cow Creek; a discussion of Area D future mining impacts on Cow Creek has been added (Chapter III, Hydrology).

Q--Identification of agricultural impacts in a more specific manner are speculative, given the available information. However, the authors believe that the small changes anticipated in the headwater areas from mining would not seriously affect agricultural activities in Cow Creek. (See Sections 3.2.3.1.1.3 and 3.2.3.1.2.3.)

R--The TDS increase in the McKay coal overburden is a significant change and may constitute a violation of Montana's groundwater standards if evidence could conclusively demonstrate a point source (industrial ponds) to the cause.

E Why doesn't Table 2.2.1 indicate and transmissivity and H20 conductivity values for Cow CreeK?

F In the discussion on Rosebud overburden, the DEIS states that data from one well indicates a low rate of flow thru the area. Is data from only one source enough to extrapolate from?

G The DEIS states that the wide range of transmissivity in the Rosebud coals due to an inconsistant fracture pattern. Would this fracture pattern be found in the Rosebud coal in the area of the proposed fly ash pond for Colstrip Units 3&4?

H Table 2.2.2 seems to be missing range desigination coordinates. It is also not clear if this table includes proposed industrial ponds for units 3&4.

I The brief discussion of groundwater quality at 2.2.1.3 strengthens our contention that all industrial facilities at the Colstrip Complex must be included to fulfill the mandate of the law.

J We take strong exception to the upper limits of TDS concentrations listed on p. 2-37. What other sources were reviewed? Does EPA have a redbook with guidelines on this kind of tolerance? We suggest 1974 National Academy of Sciences: "Nutrients and toxic substances in water for livestock use".

K Again, the high concentrations of TDS in the interburden aquifer wells noted on p.2-40 indicates the necessity to include industrial facilities in the baseline hydrologic assessment.

L On p. 2-62 there is listed the factors that explain why potential losses exceed the amount of water contributed. Are the flows from the present and proposed fly ash pond considered as contributors?

M Air Quality: Will the final EIS include an analysis of WECo's mine wide dust suppression plan?

Impacts

N Why weren't "worst case" and "best case" stresses from the proposed fly ash pond included in the analysis? The amounts of seepage from existing facilities is factored with a certain degree of uncertainty, isn't it?

O Further, was the constituent make-up of the existing fly ash pond considered when it was determined that this ponds contributions to water quantity and quality was insignificant? We are adament that these ponds be included in the analysis, anything less is neither comprehensive or cumulative.

P On p. 3-18, it is noted that well changes in the alluvial groun water system can be expected to increase for 5-25% (TDS) from mining. And yet, on p3-18 last paragraph, it is stated that mining has not or is not expected to change alluvial groundwater quality. Isn't this inconsistant with the 5-25% change? Also, is this from all mining at Colstrip, or just Area E as indicated later?

E--Hydraulic data for Cow Creek Valley Fill have been added to Table 2.2-1.

F--The pump tests on well WX 101 included drawdown measurements of four wells located around WX 101. This type of test is different from the other 22 aquifer pump tests done in overburden at the Rosebud Mine and, therefore, was mentioned separately. The reason for this well battery test was to determine the source and aquifer characteristics of groundwater feeding the spring in section 8 of Area B. (See revised text.) Collectively, all 23 wells were used to describe the transmissivity characteristics of the Rosebud overburden.

G--Six test wells drilled within the boundaries of the proposed 3 and 4 power units fly ash pond (located in the Cow Creek drainage) lost large amounts of water during packer tests. The high loss of water during packer test is indicative of voids and/or fractures in the sandstone underlying the pond. (Department of Natural Resources and Conservation responses to comments made by Montana Power Company on DNRC's review of MPC proposed fly ash pond design, DNRC on-file report, 1983).

H--The missing numbers have been added. The industrial ponds proposed for units 3 and 4 are discussed in Section 3.2.3, Chapter III, Cumulative Hydrologic Impacts.

I--Your comment is noted. Thank you.

J--One of the tables has been revised to incorporate the suggested limits for livestock used by the Montana Department of Livestock, Diagnostic Laboratory in evaluating water quality (source: National Academy of Sciences, 1974). The McKee and Wolf reference was retained since it specifies the suggested upper limits for the various livestock. We have reviewed the National Academy's report you referenc and found the Academy's safe limit for salts in water agrees very well with those listed by McKee and Wolf. Safe limits for salinity are reported lower if the only salts present are sodium sulfate, which is not the case for Colstrip waters (5,000 mg/l (ppm) upper limit for sodium sulfate). (See Appendix B, Table 1.)

K--The industrial ponds have been included in the text. (See chapter III, Section 3.2.3.)

Q Why does the DEIS only compare the "overall agricultural viability of the Colstrip region" when discussing impacts to Cow Creek?(p.3-33 para 6)

R Again it is noted that poor quality water has raised the TDS levels in the Rosebud?Mckay interburden from 2,000 TDS to about 7,000 TDS. (p. 3-33 para 7) Is this not significant? Was it included in the analysis? Doesn't the increase in TDS note above, and the projected TDS increase noted on 3-34 para 2 constitute a violation of state groundwater law?

S The DEIS states that "the overall land use pattern of the Colstrip region would not change as a result of groundwater quality changes(p. 3-35 para 1). Isn't this precluding ranchers from using practical irriagable acreage at a later date? The DEIS notes that the raise in TDS levels will not harm livestock (which we disagree with), but will preclude irriagation.

We have some serious question with many of the conclusions reached in the DEIS, and will use the following as an example:

T The DEIS states: "no data are available to estimate the seepage from the ponds to the valley fill aquifer"(p. 3-39 para 4) But just several paragraphs later, the DEIS summerizes: "the seepage from sediment ponds to the valley fill groundwater system is not expected to affect the quantity or quality of the valley fill aquifer" How does the State justify such a conclusion after stating that there is no data available?

U The DEIS states in several places that surface waterimpacts are more likely to be caused by non-mining activities than mining. This analysis couldn't do a better job of arguing our case that it is ompossible to set up an adequate baseline to determine material damage to hydrology and to predict cumulative impacts without including all industrial facilities in the analysis.

V The socio-economic analysis represents an excellent analytical approach, but several assumptions must be reconsidered. Montco's proposed schedule has slipped. Wouldn't this alter the assumptions of where the work force will come from, etc? Further, we suggest that you consider the fact that the work force at Colstrip is union, and there is a strong possibility that Montco will be non-union.

W We appreciate the efforts at projecting slowdown and cessation impacts. We question the validity of using so many "will form" "will remain" statements in this section. Wouldn't may or might be more appropriate and accurate?

X On p. 3-124, the "poor water quality" of the Tongue River is referred to. Would you please explain this statement? What analysis has been done that rates the Tongue as "poor water"?

Y How can the DEIS when discussing air quality impacts contend that (p. 4-1) that "all State and Federal Standards would be met"? Isn't Colstrip a non-attainment area?

S--Groundwater supply and quality have been unsuitable for irrigation in the Colstrip area since before mine/industrial development; therefore, the changes anticipated would not preclude the use of water in the future for irrigation because supplies are inadequate and unsuitable for irrigation. Please see Sections 3.2.3.1.1.3 and 3.2.3.1.2.3 for discussion of water quality effects on livestock.

T--Data are available for seepage rates from sediment ponds at the Rosebud Mine. However, reasonable assumptions were made on the basis of known hydrologic and geologic characteristics of the alluvium. Analyses based on the assumptions showed no noticeable adverse effects in East Fork Armells Creek. (See Section 3.2.2.1.3.)

U--See Section 3.2.3.2 for a discussion pertaining to your comment.

V--The slippage (see also letter #6, response A) will have no significant effect on the magnitude of the impact projection, only on its timing. Only the construction work force composition is affected by the timing of the project. The small increase in nonlocal construction workers--perhaps as many as 60 workers--in year two of the Montco construction schedule would have no significant effect on the magnitude of the impact. Union status of the workers at Montco would be decided by those workers and would have no significant effect on the impact projection.

W--See changes in text. The changes reflect a decision to use "will" for the assumptions used to predict developments and "would" or "could" for predicted outcomes.

X--This statement is in error and has been deleted from the text. Water-quality data for the Tongue River shows it to be fairly good quality over its entire length.

Y--Although the Colstrip area is presently designated non-attainment, recent monitoring data indicate compliance with the ambient air quality standards. The modeling described in the Draft Comprehensive environmental impact study shows no significant impact to the air quality in Colstrip. The Montana Air Quality Bureau anticipates the area will be redesignated attainment in the near future.

Z We would like to know how the State concludes that raising TDS levels from around 3,000 to aprroximately 6,200 would only result in "slightly higher salt levels"?(p.4-1)

Z--The text in Section 4.0 has been revised. Also, see Section 3.2.3 for further discussion.

AA In conclusion, we reiterate the points made in our opening statement, that as far as hydrology is concerned, this document is neither comprehensive or fills the role of a cumulative assessment.

We do appreciate the opportunity to comment.

AA--Comment noted. Text has been revised and expanded.

Respectfully,

Russ Brown
NPRC Staff

9.0 REFERENCES

Following is a list of the books, articles, pamphlets, and personal communications cited in the study. Also, cited, but not listed here, is the "technical support document" on which the study is based. This document, developed specifically to analyze Western Energy's comprehensive mine plan, is available in Helena, Billings, Forsyth, and Denver for public review. (See Consultation and Coordination.)

Adamick, Jerry, 1982. Supervisor, Rosebud Community Hospital, Forsyth, Montana. Personal communication, July 1.

Adams, L.M. et al., 1974. Coal mine spoil and refuse bank reclamation with powerplant fly ash, in Third Mineral Waste Utilization Symposium, Chicago, Illinois, March 14-16, 1972, pp. 105-111.

Angel, P.N., 1973. A soil analysis of the strip mine spoil bank at Fairfield, Texas. Stephen F. Austin State University, Nacogdoches, Texas, M.S.F. thesis. 72 p.

Ash, Robert, 1982. Sheriff, Rosebud County Sheriff Department, Forsyth, Montana. Personal communication, January 6.

Axetell, Kenneth, Jr., and Chatten Cowherd, Jr., 1981. Improved emission factors for fugitive dust from western surface coal mining sources, Vol. II emission factors. Prep. by PEDCO and MRI for EPA-IERL, Cincinnati, Ohio. November.

Backer, R.R. et al., 1977. Physical properties of western coal waste materials. U.S. Bureau of Mines Report of Investigations 8216. 29 p.

Barrett, James et al., 1979. Procedures recommended for overburden and hydrologic studies of surface mines: Final Report, Vol. I, SEAM Thunder Basin Study. Contracts No. 16-815-GR and 16-816-GR for the U.S. Forest Service. 182 p.

Barth, R.C., L.G. Cox, A. Giardinelli, S.M. Sutton, and L.C. Tisdel. 1981. State-of-the-Art Guidelines for Surface Coal Mine Overburden Sampling and Analysis--Phase I Draft Report--Survey of Current Methods and Procedures. Prepared for U.S. Department of the Interior, Office of Surface Mining, Washington, D.C. Under review, no publication date set. Available for review at Department of State Lands, Helena, Montana.

Barthauer, G.L. et al., 1971. Control of mine drainage from coal mine mineral wastes. Phase I Hydrology and related experiments. Prepared by Consolidation Coal Co. EPA Water Pollution Control Research

Begin, Z.B., and S.A. Schumm, 1979. Instability of alluvial valley floors: A method for its assessment. Trans. Amer. Soc. Agr. Eng., pp. 347-350.

References (Continued)

Benson, M.A. and Dalyrumple, T., 1976. General field and office procedures for indirect measurements. Techniques of water resources investigations. Book 3, Chapter A1. U.S. Geological Survey.

Bilbro, John, 1982. Supervisor, Rosebud County Shop, Forsyth, Montana. Personal communication, June 30.

Blad, B.L., and N.J. Roseberg, 1974. Evapotranspiration by subirrigated alfalfa and pasture in the east central Great Plains. Agron. Jour. (66), pp. 248-252.

Blaney, H.F., and W.D. Criddle, 1950. Determining water requirements in irrigated areas from climatological and irrigation data. U.S. Dept. of Agriculture, SCS. 96 p.

Bohn, Russell, and Chatten Cowherd, Jr., 1977. Fugitive dust emissions evaluation for Montana Power Company. Prep. by Midwest Research Institute, Kansas City, Missouri. Project No. 5-1655-6. 15 p.

Bond, E.W., 1975. A study of the influence of seismic shotholes on groundwater and aquifers in eastern Montana. Montana Bureau of Mines and Geology.

Botz, M.K., 1978. Characteristics and potential impact of wastewaters from a coal-fired plant at Colstrip, Montana: Report to Water Quality Bureau. Montana Department of Health and Environmental Sciences. 67 p.

Botz, M.K., and E.W. Bond, 1966. Index map and bibliography of groundwater studies in Montana. USGS Special Publication #37.

Botz, M.K., and D. Parker, 1979. Western Energy Company alluvial valley floor assessment mining, Area B, draft copy. Western Technology & Engineering, Inc.

Botz, M.K, and Dick Pederson, 1977. Summary of water quality criteria. Water Quality Bureau draft report. (Unpub.)

Granson, F.A., Botanist, U.S.G.S. Water Resources Division, Denver, Colorado. Personnal communication on numerous occasions, January and February, 1982.

Bricco, Dan, 1981. USDA Bureau of Land Management, Miles City, Montana. Personal communication, December 22.

Bursheim, Dean. 1982. Chief, Colstrip Volunteer Fire Department, Colstrip, Montana. Personal communication, November 22, 1982.

Burt, W.H., and R.P. Grossenheider, 1964. A field guide to the mammals. 2nd ed. Boston: Houghton Mifflin.

Call, M.W., 1978. Nesting habitats and surveying techniques for common western raptors. Bureau of Land Management, Denver, Colorado. 115 p.

References (Continued)

Campbell, Murdo, 1982. Administrative Officer, Montana Coal Board, Montana Department of Commerce, Helena, Montana. Personal communication, May 25.

Cannon, M.R. (No date). Hydrology of the Snider Creek drainage basin, southeastern Montana. USGS: Water-Resources Investigations report (in preparation).

Caruccio, F.T., 1973. Characterization of strip mine drainage by pyrite grain size and chemical quality of groundwater, in Ecology and Reclamation of Devastated Land. Russell Hutnik and Grant Davis (eds.), pp. 193-226.

Catapano, M.S., 1982. Physician, Colstrip Medical Clinic, Colstrip, Montana. Personal communication, January 6.

Clark, F.C., C.V. Cole, and R.A. Bowman, 1980. Nutrient cycling in Grasslands, systems analysis and man. (A.J. Breymeyer and G.M. Van Dyne, eds.) Cambridge University Press, Massachusetts.

Clave, Linda. 1982. Clerk, Colstrip School District #19, Colstrip, Montana. Personal communication, November 17, 1982.

Coates, D.A., 1980. Formation of clinker by natural burning of coal beds in the Powder River Basin, Wyoming and Montana, in Proceedings of the Fourth Symposium on the Geology of Rocky Mountain Coal. Colorado Geological Survey, Resource Service 10, pp. 37-40.

Coefield, Tom, 1982. Montana Department of State Lands. Personal communication, February 5.

Colbert, Bill, 1982. Planning and research traffic operations section, Montana Department of Highways, Helena, Montana. Pesonal communication, January 29.

Colorado School of Mines Research Institute, 1980. Soil-depth requirements for reclamation of surface mined areas. 1979 Progress report to U.S. Bureau of Mines, Project No. J60358. 50 p.

Colstrip Area Recreation and Parks Association, 1980. CARPA Recreation Guide, 1980 and 1981, Colstrip, Montana.

Conenberg, J.G., 1981. Common plants of the Colstrip area. In-house document, Western Energy Co., Rosebud, Montana.

Connell, John, 1982. Christian-Spring-Sielbach and Associates, Billings, Montana, Personal communication, July 28.

Cook, C.W., Hyde, R.M., and P.L. Simms, 1974. Revegetation for surface mined areas. CSU Range Science Dept. Sciences Series #6.

References (Continued)

Cook, Frank, and William Kelly, 1976. Evaluation of current surface coal mining overburden handling techniques and reclamation practices. Prep. by Mathematica, Inc., Princeton, N.J. U.S. Bureau of Mines Contract No. S0144081. Final report. 318 p.

Craig and Turelle, 1 964. Guide for wind erosion control on cropland in the Great Plains states. U.S. Department of Agriculture, Soil Conservation Service, July.

Curtis, W.R., 1973. Moisture and density relations on graded strip-mined spoils. Paper II-1, in Ecology and Reclamation of Devastated Land. Hutnik, R.J., and Grant David (eds.). New York: Gordon and Breach, Vol. 1, pp. 135-144.

Dale, Rick, 1982. Western Energy Company, Colstrip, Montana. Personal communication, January 6.

Daniels, L.A. 1978. Soil Survey Party Leader, Rosebud County Soil Survey, USDA Soil Conservation Service, Forsyth, Montana. Written Communication, April 17.

Davenport, Michael, 1981. Air compliance inspection report for Colstrip Units 1 and 2 on July 29, 1980. Prep. for U.S. Environmental Protection Agency - Montana office, Helena, Montana.

Davis, R.E. (No date). Series of interim data and interpretive reports. Decker and Big Sky Mines, Montana (in preparation).

DePuit, E.J., 1980. Recent progress in mined land revegetation research in Montana presented at symposium on adequate reclamation of mined lands, Billings, Montana, March 26-27, 1980. Soil Conservation Society of America and WRCC-21.

DePuit, C.E. and J.G. Conenberg, and C.L. Skilbred, 1980. Establishment of diverse native plant communities on coal surface mined lands in Montana as influenced by seeding method, mixture, and rate. Montana State University, Agricultural Experiment Station, Research Report 163.

Dobbins, C.E. and C.E. Erdman, 1955. Structure contour map of the Montana Plains. USGS)&G inv. map. OM 178B.

Dockins, W.S. et al., 1980. Sulfate reduction in groundwater of southeastern Montana. USGS: Water-Resources Investigations 80-9. 13 p.

Dolhopf, D.J. et al., 1977. Effects of surface configuration in water pollution control on semiarid mined lands. Montana State University, Agricultural Experiment Station, Research Report 114. 179 p.

_____, Hydrologic research at the Big Sky Mine, I. Coalbank Coulee Hydrology, II. Reservoir feasibility in spoil reclamation. Montana Agricultural Experiment Station progress report, Montana State University, Bozeman, Montana.

References (Continued)

_____, 1977. Progress report, hydrologic research at Big Sky Mine. Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana.

_____, 1977. Selective placement of coal strip mine overburden in Montana, Vol. 1. Data base: Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana.

_____, 1978. Selective replacement of coal strip mine overburden in Montana, Vol. 2, Initial field demonstration, in Montana Agricultural Experiment Station Research Report #125, Montana State University, Bozeman, Montana.

_____, 1978. Selective placement of coal strip mine overburden in Montana, Vol. 3., Spoil mixing phenomena, in Research Report #135, Montana State State University and Agricultural Experiment Station, Bozeman, Montana. 68 p.

_____, 1978. Selective placement of coal strip mine overburden in Montana in Research Report #128, Montana State University and Agricultural Experiment Station, Bozeman, Montana. 109 p.

_____, 1979. Hydrogeology of a watershed with subirrigated alluvial materials in crop production, Vol. 1, mined land reclamation. Montana Agricultural Experiment Station, Bulletin 715, Montana State University, Bozeman, Montana. 6 p.

_____, 1979. Selective placement of coal strip mine overburden in Montana: Vol. 4, hydrogeologic studies. Montana Agricultural Experiment Station, Montana, State University, Bozeman, Montana.

_____, 1981. Selective placement of strip mine overburden in Montana. V Summary Report.

Douglas, Patricia, 1982. Research specialist, Montana Department of Commerce, Helena, Montana. Personal communication, January 28.

Duell, Steve, 1982. Supervisor, Rosebud County Emergency Medical services, Forsyth, Montana. Personal communication, July 1.

Durham, Ray, 1982. Colstrip Fire Chief, Colstrip Fire Department, Colstrip Montana. Personal communication, February 3.

Ecological Consulting Service, 1972. Preliminary wildlife and ecological report for Western Energy Company and Stearns-Roger Corp. of Areas A, B, and certain spoils, Colstrip, Montana. Helena, Montana.

_____, 1973. Wildlife investigations, Areas D and E, Colstrip, Montana. Project 13-01-A. Annual report to Montana Power Company and Western Energy Company. Helena, Montana.

References (Continued)

_____, 1974. 10 x 20 Colstrip annual report to the Montana Power Company. Project 71-23-A. Helena, Montana.

_____, 1975. The Montana Power Company Colstrip 10 x 20 area wildlife and wildlife habitat annual monitoring report. Project 71-23-A. Helena, Montana.

Ferber, A. E., 1974. Windbreaks for conservation. U.S. Department of Agriculture, Soil Conservation Service, Agricultural Information Bulletin 339.

Flath, D.L., 1981. Vertebrate species of special interest or concern. Wildlife Division, Montana Department of Fish, Wildlife, and Parks. Bozeman, Montana.

Foch, J.D., Jr., and G.S. Oliver, 1980. Technical report on sound levels in Bryce Canyon National Park and the noise impact of the proposed Alton coal mine. Prep. by the Noise Technical Assistance enter of the of the University of Colorado in Boulder for the National Park Service and the Environmental Protection Agency.

Forsyth, City of. 1970, 1981. Town Clerk's Annual Financial Statement to to State Examiner. Forsyth, Montana.

Forsyth, City of. 1970, 1980. Town of Forsyth Audit Report. Forsyth, Montana.

Fredlund, D.E., 1972. 1971 archaelogical survey, Western Energy Company lands, Rosebud County, Montana. University of Montana Statewide Archaeological Survey, Missoula, Montana.

Fredlund, D.E., 1976. Archaeological survey Sec. 29, T2N, R41E for Western Energy Company. Mineral Research Center, Montana College of Mineral Science and Technology Foundation, Butte.

Fredlund, L.B., 1977. Archaeology of East Decker and the North Extension. Division of Archaeology and Cultural Resources, Mineral Research Center, Montana Tech Alumni Foundation Reports of Investigations No. 4., Butte.

_____, 1979. Results of cultural resource projects on Western Energy Company Area A and Area A Extension, Rosebud County, Montana. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

_____, 1979. Reassessment of cultural resources, Area E, sections 1, 2, 11 and 12, T1N, R41E Western Energy Company lands. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

_____, 1980. The buffer zone for Western Energy Mining Area E: section 2 and portions of 1, 3, 11 and 12. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

References (Continued)

_____, 1980. Cultural resources inventory and assessment: mining Area C extension and one-mile buffer. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte, Montana.

_____, 1980. Archaeology report on Area B sections 7, 8, 17, and 18, T1N R41E; sections 12 and 13, T1N R40E. Cultural Resources Division, Montana. Tech Alumni Foundation, Butte, Montana.

_____, 1982. Personal communication.

Fredlund, L.B., and D.E. Fredlund, 1974. Western Energy Company archaeological investigations, Rosebud County, Montana, 1973. Montana College of Mineral Science and Technology Foundation, Mineral Research Center, Butte, Montana.

Fredlund, L.B. and Staff, 1980. Cultural resources on Area B - sections 4, 9, and 10. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

_____, 1980. Cultural resources on Area B - sections 7, 8, 17 and 18. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

_____, 1980. Cultural resources on Area B - sections 4, 9 and 10. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

_____, 1980. Cultural resource inventory and evaluation in the Montco study area, southeast Montana. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

Frickel, D.G., L.M. Shown, and P.C. Patton, 1975. An evaluation of hillslope and channel erosion related to oil shale development in the Piceance Basin, northwestern Colorado. Colorado Water Resources #30, Colorado Department of Natural Resources, Denver.

Gabel, Terry, 1982. Emergency Medical Service, Colstrip, Montana. Personal communication, January 21.

Geer, M.R., 1969. Disposal of solid wastes from coal mining in Washington, Oregon, and Montana. U.S. Bureau of Mines Information Circular 8430. 39 p.

Gelhaus, J.W., 1980. Executive summary of air quality and meteorology monitoring program, 1978-79. Westmoreland Resources, Absaloka Mine.

_____, 1981. Meteorological summary. Billings, Montana Air Pollution Study, Air Quality Bureau, Montana Department of Health and Environmental Sciences, Helena, Montana.

Gold, R.L., 1974. A social impact study of Colstrip generating plants #3 and #4. Community Service Program, University of Montana, Missoula, Montana.

References (Continued)

Gold, R.L., 1974. Social impact of existing and proposed coal development: a survey of Rosebud County study area residents. Community Service Program, University of Montana, Missoula, Montana.

Gold, R.L., 1975. The Decker Mine proposals: social and social services analysis. Institute for Social Research, University of Montana, Missoula, Montana.

_____, 1975. A study of social impact of coal development in the Decker-Birney Ashland area. Community Service Program, University of Montana, Missoula, Montana.

Good, D.M. et al., 1970. The relation of refuse pile hydrology to acid production, in Third Symposium on Coal Mine Drainage Research, May 19-20, 1970. Mellon Institute, Pittsburgh, Pennsylvania, pp. 145-151.

Greb, B.W., 1977. Principles of fall weed control and residue management in a fallow winter wheat rotation. Proceedings of ECO-Fallow Conference, Great Plains Council, McCook, Nebraska, March 8.

Grimm, Carlton, 1980. Montana Power Company's plan for controlling dust from coal handling. Letter to Montana Department of Health and Environmental Sciences, March 25.

Groenewold, G.H., 1979. Hydrologic and hydrochemical characterization of selected strip mine spoils in western North Dakota, in Ecology in Coal Resource Developments. Wali, M.K. (ed.). New York: Pergaman Press.

Groenewold, G.H., and B.W. Rehm, 1980. Instability of contoured surface mined landscapes in the Northern Great Plains: Causes and Implications in Proc. Symposium: "Adequate Reclamation of Mined Lands." Soil Conservation Society of America. March 1980. P. 2-1 to 2-15.

Hadley, R.F., and S.A. Schumm, 1961. Sediment sources and drainage basin characteristics in the Upper Cheyenne River Basin, USGS: Water Supply Paper 1531-1538. 198 p.

Hadley, R.F., D.G. Frickel, L.M. Shown, and R.C. Miller, 1981. Methodology for hydrologic evaluation of a potential surface mine: East Trail Creek Basin, Big Horn County, Montana. U.S.D.I., Geological Survey. WRI/OFR 81-58.

Hall, E. Raymond, 1981. The mammals of North America. 2nd ed. Two Volumns. New York: John Wiley & Sons.

Hamilton, D.A., and J.L. Wilson, 1977. A generic study of strip mining impacts on groundwater resources. Massachusetts Institute of Technology, Department of Civil Engineering, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics. Report No. 229 (R-77-28). 156 p.

References (Continued)

Hanchette, C. and S.D., 1982. Review of the cultural resources work at Rosebud Mine: A file memo. Professional Analysts, Eugene.

Hansen, E.A., and A.R. Harris, 1975. Validity of soil-water samples collected with porous ceramic cups. Soil Sci. of Am. Proc., Vol. 39, No. 3.

Hardaway, J.E. et al., 1977. Subirrigated alluvial valley floors, in Proceedings of the Fifth Symposium on Surface Mining and Reclamation, Louisville, Kentucky, pp. 61-135.

Haynes, R.J., and W.D. Klimstra, 1975. Some properties of coal spoilbank and refuse materials resulting from surface mining coal in Illinois. Institute for Environmental Quality, State of Illinois.

Heimbach, J.A. and A.B. Super, 1973. Air pollution potential determination program for Colstrip, Montana. Department of Earth Sciences, Montana State University.

Hill, R.D., 1973. Water pollution from coal mines, presented at Forty-Fifth Annual Conference of the Water Pollution Control Association of Pennsylvania.

_____, 1976. Sedimentation ponds: A critical review, in Proceedings of the Sixth Symposium on Coal Mine Drainage Research, October, 1976, pp. 190-199.

Hillman, C.N. and W.W. Jackson, 1973. The sharp-tailed grouse in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre, South Dakota. 62 p.

Hodder, R.L., 1975. Montana reclamation problems and remedial techniques, in Practices and Problems of Land Reclamation in Western North America. Wali, M.K. (ed.). University of North Dakota Press, Grand Forks, N.D., pp. 90-106.

Hofeldt, Mrs. Paul, 1982. Member of School Board, District No. 19, Colstrip, Montana. Personal communication, January 4.

Holzworth, G.C., 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. Environmental Protection Agency.

Hornick, S.B., D.E. Baker, and S.B. Guss, 1977. Crop production and animal health problems associated with high soil molybdenum in Molybdenum in the environment. W.R. Chappell and K.K. Peterson (eds.) Marcel Dekker, Inc., New York. Vol. 2, pp. 665-684.

Horst, John, 1982. Results Engineer, Montana Power Company, Colstrip, Montana. Personal communication, February 4.

References (Continued)

Hotchkiss, W.R., 1978. Developing a hydrologic model of the shallow aquifer of the Powder River Basin, Montana and Wyoming, in Energy and the Environment: Fifth National Conference Proceedings, Cincinnati. Nichols, E.G., et al. (eds.). Dayton Section, American Institute of Chemical Engineers, pp. 212-217.

Howard, C., 1982. Montana Department of State Lands. Personal communication, March 26.

Hughes, W.C., 1978. Estimating the risk of channel erosion, in Proceedings of the 26th Annual Hydraulics Division Specialty Conference, American Society of Civil Engineers, University of Maryland, College Park, Md. August 9-11, pp. 568-573.

Hunter, Harold, 1982. Woodland Conservationist, Montana Soil Conservation. Personal communication, January 12.

Hydrometrics, Inc., 1980. Investigation of potential mining on a portion of the East Fork Armells Creek alluvial aquifer in Area B, Rosebud Mine, Colstrip Montana. Prepared for Western Energy Company.

_____, 1976. Sedimentation ponds: A critical review, in Proceedings of the Sixth Symposium on Coal Mine Drainage Research, October, 1976, pp. 190-199.

Hillman, C.N. and W.W. Jackson, 1973. The sharp-tailed grouse in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre, South Dakota. 62 p.

Hodder, R.L., 1975. Montana reclamation problems and remedial techniques, in Practices and Problems of Land Reclamation in Western North America. Wali, M.K. (ed.). University of North Dakota Press, Grand Forks, N.D., pp. 90-106.

Hofeldt, Mrs. Paul, 1982. Member of School Board, District No. 19, Colstrip, Montana. Personal communication, January 4.

Holzworth, G.C., 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. Environmental Protection Agency.

Hornick, S.B., D.E. Baker, and S.B. Guss, 1977. Crop production and animal health problems associated with high soil molybdenum in Molybdenum in the environment. W.R. Chappell and K.K. Peterson (eds.) Marcel Dekker, Inc., New York. Vol. 2, pp. 665-684.

Horst, John, 1982. Results Engineer, Montana Power Company, Colstrip, Montana. Personal communication, February 4.

_____, 1980. Supplement to preliminary AVF investigation of East Fork Armells Creek in the vicinity of Western Energy Company's Rosebud Mine, Colstrip, Montana.

References (Continued)

_____, 1981. Exhibit R-7. Area C, Block 1, Potentially irrigable lands along East Fork Armells and Stocker Creeks. Western Energy Company's application for a surface mining permit, Area C, Block I.

_____, 1982. Cumulative Hydrologic Impacts Rosebud Mine Western Energy Company, Colstrip, Montana.

Johnson Division, UOP, Inc., 1975. Groundwater and wells. St. Paul, Minnesota. 440 p.

Johnson, M.V., 1978. Floods of June 4 and 12, 1976, at Culbertson, Montana. USGS Open-File Report 78-429. 6 p.

Johnson, MV.V., and RJ. Omang, 1976. A method for estimating magnitude and frequency of floods in Montana. USGS Open-File Report 75-650. 35 p.

_____, 1976. Floods of May-July 1975 along the Continental Divide in Montana. USGS Open-File Report 76-424. 18 p.

Johnson, M.V. et al., 1976. Annual peak discharges from small drainage areas in Montana through September 1975. USGS Open-File Report. 204 p.

Johnson, M.V. et al., 1977. Annual peak discharges from small drainage areas in Montana through September 1976. USGS Open-File Report 77-172. 204 p.

Jones, J.K. et al., 1979. Revised checklist of North America mammals north of Mexico. Occasional Papers, The Museum, Texas Tech University, No. 62. December 14.

Kampf, Joe, 1982. Emergency Medical Service, Colstrip, Montana. Personal communication, January 26, July 1.

Keale, Linda. 1982. Administrative Officer, Human Services Project, Colstrip, Montana. Personal communication, November 16, 1982.

Keefer, W.R., 1974. Regional topography, physiography and geology of the Northern Great Plains. USGS Open-File Report 74-50.

Kelley, Jim, 1982. Construction Supervisor, Bechtel Corporation, Colstrip, Montana. Personal communication, January 6.

Kennedy, Mike, 1982. Supervisor, Rosebud County Department of Public Welfare, Forsyth, Montana. Personal communication, February 3.

Knapton, J.R., and P.W. McKinley, 1977. Water quality of selected streams in the coal area of southeastern Montana. USGS: Water-Resources Investigations 77-80. 145 p.

Knudsen, Carl, 1982. Owner, Knudsen's Ranch Wear, Colstrip, Montana. Personal communication, June 3.

References (Continued)

Konikow, L.F., and J.D. Bredehoeft, 1974. Modeling flow and chemical quality changes in an irrigated stream-aquifer system. American Geophysical Union, Water Resources Research, Vol. 10, No. 3, pp. 546-562.

Korzhinskii, D.S., 1959. Physiochemical basis of the analysis of the paragenesis of minerals. Consultants Bureau, Inc., New York.

Kubota, Joe, 1977. Molybdenum status of United States soils and plants, in Molybdenum in the environment, Vol. 2. The geochemistry cycling and industrial uses of molybdenum, W.R. Chappel and K.K. Peterson (eds.). pp 555-581.

Lahren, L.A., 1977. The impact of coal development on cultural resources in southeastern Montana. Anthro Research.

Langebein, W.B., and S.A. Schumm, 1958. Yield of sediment in relation to mean annual precipitation. American Geophysical Union Transactions (39), pp. 1076-1084.

Larson, M.M. and G.H. Schubert, 1969. Root competition between ponderosa pine seedlings and grass. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Paper RM-54.

Lee, R.W., 1979. Ground-water-quality data from the northern Powder River Basin, southeastern Montana. USGS: Water-Resources Investigations Open-File Report 79-1331. 55 p.

_____, 1980. Geochemistry of water in the Fort Union Formation of the northern Powder River Basin, southeastern Montana. USGS: Water-Resources Investigations Open-File Report 80-336. 17 p.

_____, 1980. A conceptual model of the hydrogeochemistry of the coal-bearing Fort Union Formation in southeastern Montana.

Lee, R.W. et al., 1980. Magnitude and chemical quality of base flow of Otter Creek, Tongue River, and Rosebud Creek, southeastern Montana, October 16-November 5, 1977. USGS Open-File Report 80-1298, 29 p.

Leinard, Robert, 1982. Range Conservationist, Soil Conservation Service, Miles City, Montana. Personal communication, March 25.

Lewis, B.D., and R.S. Roberts, 1978. Geology and water yielding characteristics of rocks of the Northern Powder River Basin, southeastern Montana. USGS Miscellaneous Investigations Map I-847-D, 2 sheets.

Lindsay, W.L., 1979. Chemical equilibria in soils. John Wiley and Sons, New York. 449 p.

Litke, D.W. (No date). Evaluation of suspended sediment in selected streams in southeastern Montana. USGS: Survey Water-Resources Investigations report (in preparation).

References (Continued)

Lohman, S.W., 1979. Groundwater hydraulics. USGS Professional Paper 708. U.S. Government Printing Office, Washington, D.C.

Lusby, G.C., and T.J. Toy, 1976. An evaluation of surface-mine spoils area restoration in Wyoming using rainfall simulation. Earth Surface Processes, Vol 1., pp. 375-386.

_____, 1976. An evaluation of surface-mine spoils area restoration in Wyoming using rainfall simulation. Earth Surface Processes. Vol. 2, pp. 39-54.

Maas, E.V., and G.J. Hoffman, 1977. Crop salt tolerance--current assessment. American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 163, No. IR2, pp. 115-134.

Martin, J.F., 1974. Quality of effluents from coal refuse piles, in First Symposium on Mine and Preparation Plant Refuse Disposal, at Coal and the Environment Technical Conference, October 22-24, 1974, Louisville, Kentucky. National Coal Association, Washington, D.C., pp. 26-37.

Martin, P.R., 1980. Terrestrial wildlife habitat inventory in southeastern Montana. Montana Department of Fish, Wildlife, and Parks, Ecological Services Division. Miles City, Montana.

Martin, P.R., 1981. Montana Department of Game and Fish. Personal communication, December 22.

Matson, R.E., and J.W. Blumer, 1973. Quality and reserves of strippable coal, selected deposits, southeastern Montana. Montana Bureau of Mines and Geology Bulletin 91 (1974). 135 p.

May, Barbara, 1982. Receptionist, Colstrip Dental Clinic, Colstrip, Montana. Personal communication, January 26.

McCaffree, Ed et al., 1981. Rosebud County Commissioners, Forsyth, Montana. Written communication to Western Energy Company, November 13.

McCrae, Mac, 1982. Rosebud County Commissioner, Ashland, Montana. Personal communication, June 1 and July 29.

McGinnis, Tim, 1979. Reassessment of cultural resources in Western Energy Company Area A, Rosebud County, Montana. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte, Montana.

McIntosh, G.E., 1979. Simulation of the effects of surface mining on groundwater in the Powder River Basin. U.S. Department of Interior, Bureau of Mines, Denver, Colorado, Transactions of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc. (266), pp. 385-390.

McIntosh, Larry, 1982. Office Manager, Western Energy Company, Colstrip, Montana. Personal communication, January 22.

References (Continued)

McKee, J.E., and H.W. Wolf, 1971. Water quality criteria. 2nd ed. California State Water Quality Control Board. Publ. 3-A, 548 p.

McKinley, P.W., 1979. Water quality of selected streams in the coal area of east-central Montana. USGS: Water-Resources Investigations 78-142. 49 p.

McQueen, R.F., 1982. U.S.G.S. Research Hydrologist, Denver, Colorado. Personal communication, February 8.

McWhorter, David B., date unknown. Draft copy of procedures for predictive analysis of selected hydrologic impacts of surface mining. Industrial Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. 99 pages.

McWhorter, D.B. et al., 1974. Potential of mine and mill spoils for water quality degradation. American Water Resources Association Symposium (water resources problems related to mining) Proc., Golden, Colorado, pp. 123-137.

McWhorter, D.B., and J.W. Rome 1976. Inorganic water quality in a surface mined watershed. Paper presented at American Geophysical Union Symposium on Methodologies for Environmental Assessment in Energy Development Regions. December 8, 1976, San Francisco, California.

Melton, M.A., 1958. Geometric properties of mature drainage systems and their representation in a 4E phase space. Geology (66), pp. 25-54.

Miller, I. and J.E. Freund, 1977. Probability and statistics for engineers. 2nd ed. Prentice-Hall, Inc., New Jersey.

Miller, J.F., R.H. Frederick, and R.J. Tracey, 1973. Precipitation frequency atlas of the western U.S. NOAA, Atlas 2, Vol. 1. Montana.

Miller, Larry, 1982. Sunlight Development Company, Colstrip, Montana. Personal communication, February 9.

Miller, R.M., 1982. Soil Microbiologist, Agronne National Laboratory, Argonne, Illinois. Personal communication, March 23.

Miller, R.M., and R.E. Cameron, 1976. Some effects on soil microbiota of topsoil storage during surface mining, in Fourth Symposium on Surface Mining and Reclamation. NCA/BCR Coal Conference and Expo III, Louisville, Kentucky.

Miller, W.R. 1981. Water resources of thes outhern Powder River area of southeastern Montana. Montana Bureau of Mines and Geology Memoir 47.

Miller, W.R., 1979. Water resources of the central Powder River area of southeastern Montana. Montana Bureau of Mines and Geology Bulletin 108. 65 p.

References (Continued)

Mineral Research Center, 1982. Site and MAL forms from the 1981 resurvey of Western Energy Company's Area C. Montana Tech Alumni Foundation, Butte, Montana.

Montana Board of Public Education, 1976. Standards for accreditation of Montana schools. 3rd ed. Helena, Montana.

Montana Bureau of Mines and Geology and U.S. Geological Survey, 1978. Groundwater of the Ft. Union coal region, eastern Montana. Montana College of Mineral Science and Technology. 47 p.

Montana Department of Fish and Game, 1978. 1978 Montana statewide comprehensive outdoor recreation plan (SCORP). Vol. 2. Helena, Montana.

Montana Department of Health and Environmental Sciences, 1973. Final environmental impact statement on the proposed Montana Power Company electrical generating plant (Units 1 and 2) at Colstrip, Montana. MDHES, Helena, Montana.

_____, 1979. Big Sky Mine air quality Permit Number 1350. Issued by the Air Quality Bureau of November 23, 1979. 18 p.

_____, 1980. Montana health data book and medical facilities inventory. Helena, Montana.

Montana Department of Health and Environmental Sciences, 1981. Preliminary determination of permit application No. 1570 for Western Energy Company's Rosebud Mine - Area C. Air Quality Bureau, Helena, Montana, August 6.

_____, 1974. Draft environmental impact statement on Colstrip electric generating Units 3 and 4,500 kilowatt transmission line, and associated facilities. Prep. by Energy Planning Division, Helena, Montana. Six volumes.

_____, 1974. Final environmental impact statement on Colstrip generating Units 3 and 4, 500 kilowatt transmission lines, and associated facilities. Energy Planning Division, Helena, Montana. 2,136 p.

Montana Department of State Lands, 1976. Final environmental impact statement for the proposed expansion of Western Energy Company's Rosebud mine into Area B. 153 p., appendices.

_____, 1977. Final environmental impact statement on the proposed expansion of Western Energy's Rosebud mine into Areas A and E.

_____, 1979. Draft environmental impact statement on the proposed mining and reclamation plan for Westmoreland Resources, Inc. Absoloka Mine, Big Horn County, Montana. 127 p.

_____, 1980. Draft environmental impact statement, for Western Energy Company s Rosebud Mine, Area B extension. DSL, Helena, Montana.

References (Continued)

_____, 1980. Final environmental impact statement, for Western Energy Company's Rosebud Mine, Area B extension. DSL, Helena, Montana.

_____, 1981. Final environmental impact statement, for Western Energy Company's Rosebud Mine, Area E extension. DSL, Helena, Montana.

_____, 1981. Alluvial valley floor determination for a portion of East Fork Armells Creek in the vicinity of Western Energy's Rosebud Mine. Prepared by Montana Department of State Lands, Reclamation Division.

Montana Department of State Lands. 1981. Montco Survey - 1981. Unpublished. Helena, Montana.

Montana Department of State Lands, 1982. Draft environmental impact statement for the Montco Mine. Montana Department of State Lands, Helena. May 1982. 233 p.

Montana State Coal Board, 1982. Montana Department of Community Affairs, Helena, Montana.

Montana State Historic Preservation Office, 1981. Personal communication, October 22.

Montana Superintendent's Office of Public Instruction, 1970, 1980. Helena, Montana.

Montana Taxpayers Association, 1970, 1980. Montana property tax mill levies. Helena, Montana.

Moore, L.G., and R.R. Shields, 1980. Streamflow characteristics of the Yellowstone River Basin, through 1976. USGS: Water-Resources Investigations 80-41. 67 p.

Moulton, L.K. et al., 1974. Coal mine refuse: An engineered material, in Proceedings of the First Symposium on Mine and Preparation Plant Refuse Disposal. National Coal Assoc., October 1974, pp.1-25.

Mountain West Research, Inc., 1980. Bechtel work force profile report. Billings, Montana.

Mountain West Research, Inc., 1981. Proposed MONTCO mine technical report. Billings, Montana.

Munshower, F.F. (In Press). Microelements and their role in surface mine planning. Prepared for Bureau of Land Management, Division of Special Studies.

Munshower, F.F., E.J. DePuit, and D.R. Neuman. 1978. The effects of stock emissions on the range resource in the vicinity of Colstrip, Montana--Pre-operational description of the range ecosystem. Montana Agricultural Experiment Station Research Report No. 126, Bozeman, Montana.

References (Continued)

Munson, G., 1980. Old Homestead Kill site (24RB1014). Cultural Resources Division, Montana Tech Alumni Foundation, Mineral Research Center, Butte, Montana.

Munson, Gene and Munson, Shirley M., 1980. Big Sky Mine, Peabody Coal Area A cultural resources investigation and assessment. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Reports of Investigation No. 12, Butte, Montana.

_____, 1980. Archaeological investigations at the Bunny Chase site (24BH1574). Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte, Montana.

National Academy of Sciences, 1974. Nutrients and Toxic Substances in Water for Livestock and Poultry. Washington, D.C. 93 p.

National Academy of Sciences, 1974. Rehabilitation potential of western coal lands. Boston: Ballinger Publishing Co. 341 p.

Neckers, J.W., and C.R. Walker, 1952. Field test for active sulfides in soil. Soil Sci., Vol. 74, pp. 467-470.

Norbeck, P., 1982. Western Energy Company, Colstrip, Montana. Personal communication.

Noyd, M., 1982. CARPA Recreation Director, Colstrip, Montana. Personal communication, January 7 and February 4.

Ogata, G. and Ca. A. Bower, 1965, Significance of biological sulfate reduction in soil salinity. Soil Sci. Soc. Ameri., Proc. (29), pp. 23-25.

Omang, R.J., and J.A. Hull, 1978. Annual peak discharges from small drainage areas in Montana through September 1977. USGS Open-File Report 78-219. 204 p.

Omang, R.J. et al., 1979. Annual peak discharges from small drainage areas in Montana for stations discontinued before 1978. USGS Open-File Report 79-510. 124 p.

_____, 1979. Annual peak discharges from small drainage areas in Montana through September 1978. USGS Open-File Report 79-522. 114 p.

_____, 1980. Annual peak discharges from small drainage areas in Montana through September 1979. USGS Open-File Report 80-340. 114 p.

Pacific Northwest Utilities Conference Committee, 1981. Northwest regional foreast of power loads and resource, July 1981-June 1982.

Pacific Southwest Inter-Agency Committe, 1968. Report on factors affecting sediment yield in the Pacific Southwest area. Water Management Committee Sedimentation Task Force. 10 p.

References (Continued)

Palm, Sue, 1982. Receptionist, Colstrip Medical Clinic, Colstrip, Montana. Personal communication, January 26.

Parrett, Charles et al., 1978. Data for floods of May 1978 in northeastern Wyoming and southeastern Montana. USGS Open-File Report 78-985. 16 p.

Parrett, C., and R.J. Omang, 1981. Revised techniques for estimating magnitude and frequency of floods in Montana. USGS Open-File Report 81-917.

Patton, P.C., and S.A. Schumm, 1975. Gully erosion in northern Colorado: A threshold phenomenon. Geology (3), p. 88-90.

_____, 1981. Ephemeral stream processes: Implications for studies of Quaternary valley fill. Quat. Res. (15), pp. 24-43.

PEDCO - Environmental, Inc., 1975. Montana AQMA area source emission inventory. Contract No. 68-02-1375 for the U.S. Environmental Protection Agency, Region VIII, Denver, Colorado. 160 p.

_____, 1976. Particulate and SO2 emission inventory for non-AQMA counties in Montana. Prep. for Montana Department of Health and Environmental Sciences. Contract No. 0630. 47 p.

_____, 1976. Microinventory for Montana Power Site No. 3, Colstrip, Montana. Prep. for U.S. Environmental Protection Agency - Region VIII, Denver, Colorado. 6 p.

_____, 1977. Southeastern Montana coal resource AQMA analysis. Contract No. 68-02-1375 for the U.S. Environmental Protection Agency, Region VIII, Denver, Colorado. 52 p.

_____, 1978. Survey of fugitive dust from coal mines. Prep. for U.S. Environmental Protection Agency Region VIII, Denver, Colorado. Publ. No. EPA-908/1-78-003, February.

_____, 1981. Improved emission factors for fugitive dust from western surface coal mining. EPA Report Contract No. 68-03-2924.

Pennington, Dennis, 1975. Relationship of groundwater movement and strip mine reclamation, in Third Symposium on Surface Mining and Reclamation, at NCA/BCR Coal Conference and Expo II, October 21-23, 1975, Louisville, Kentucky. National Coal Association, Washington, D.C. Vol. 1, pp. 170-178.

Peterson, Jim, 1982. Assistant Director, Eastern Montana Community Mental Health Center, Miles City, Montana. Personal communication, February 3.

Peterson, R.T., 1961. A field guide to western birds. 2nd ed. Boston: Houghton Mifflin.

References (Continued)

Pietz, R.I. et al., 1974. Groundwater quality at a strip mine reclamation area in west central Illinois, in Second Research and Applied Technology Symposium on Mined-land Reclamation, at Coal and the Environment Technical Conference, October 22-24, 1974, Louisville, Kentucky. National Coal Association, Washington, D.C., pp. 124-144.

Plummer, N. et al., 1976. WATEQF: A Fortran IV version of WATEQ, a computer program of calculating chemical equilibrium of natural waters. NTIS PB-261 027, Reston, Virginia.

Polley, Gloria, 1982. Rosebud County Department of Public Welfare, Forsyth, Montana. Personal communication, January 25.

Polzin, P.E., 1981. Rosebud County and energy development: Boom without bust? Montana Business Quarterly, Bureau of Business and Economic Research, University of Montana, Missoula, Montana.

Polzin, Paul E., 1981. Projected Trends in the Population/Employment Ratio 1985-2005: a Simulation Study. Missoula, Montana.

Porter, Margaret, 1982. Optometric Assistant, Colstrip Optometric Clinic, Colstrip, Montana. Personal communication, January 26.

Potter, Mike, 1982. Wirth Associates, Inc., Billings, Montana. Personal communication, August 6.

Prinkki, Ron, 1982. Agriculture, Stabilizaton and Conservation Service, County Executive Director, Forsyth, Montana. Personal communication, February 1.

Rahn, P.H., 1975. Groundwater in coal strip-mine spoils, Powder River Basin in Proceedings of Fort Union Coal Field Symposium, Montana Acad. Sci., Vol. 3, Reclamation sec., pp. 348-361.

Ralston, D.S., and Wiram, V.P., 1978. The need for selective placement of overburdan and equipment considerations. Mining Congress Journal, Vol. 64, No. 1, pp. 18-24. (481D) (FP, PP)

Ramsey, J.P., 1969. Control of pollution from coal mine refuse sites and slurry ponds. AIME Society of Mining Engineers meeting, September 17-19, 1969, Salt Lake City, Utah. Preprint No. 69-F-330. 4 p.

_____, 1970. Control of acid pollution from coal refuse piles and slurry lagoons, in Third Symposium on Coal Mine Drainage Research, May 19-20, 1970, Mellon Institute, Pittsburgh, Pennsylvania, pp. 138-144.

Randall, J., 1982. Engineer, Montana Department of Highways, Miles City, Montana. Personal communication, February 1.

Reardon, Pat, 1982. Manager, Real Estate and Services, Sunlight Development Company, Colstrip, Montana. Personal communication, January 4, January 7, February 9.

References (Continued)

Renick, B.C., 1929. Geology and Ground-Water Resources of Central and Southern Rosebud County, Montana, (Chemical Analysis of the Waters by H.B. Rittenburg), U.S. Geological Survey, Water Supply Paper 600, U.S. Government Printing Office, Washington, D.C. 140 p.

Rice, Eldon, 1982. Rosebud County Planning Officer, Forsyth, Montana. Personal communication, January 8, February 11, June 2, July 29.

Richardson, Nancy, 1981. Stand structure and patterns of conifer regeneration near Colstrip, Montana. M.S. thesis, University of Montana, Missoula, Montana. 122 p.

Robbins, C.S., Bertel Bruun, and Herbert S. Zim, 1966. Birds of North America. Western Publishing Company, Inc., Racine, Wisconsin.

Roberts, Patricia, 1982. Montana Department of Administration, Helena, Montana. Personal communication, May 13.

Rogowski, A.S., and L. Jacoby, Jr., 1977. Water movement through Kylertown strip mine spoil. American Society of Agricultural Engineers, Annual Meeting, June 26-29, 1977, Raleigh, North Carolina. Paper No. 77-2057. 24 pp.

Rogowski, A.S. et al., 1977. Modeling the impact of strip mining and reclamation processes on quality and quantity of water in mined areas: A review. Journal of Environmental Quality, Vol. 6, No. 3, pp. 237-244.

Rose, Charles M., 1982. Area C Project Coordinator, Western Energy Company, Billings, Montana. Personal communication, January 8.

Rosebud, County of, 1970, 1980. Rosebud County Clerk's annual financial report. Forsyth, Montana.

_____, 1970, 1980. Rosebud County audit report. Forsyth, Montana. Rosebud County Bicentennial Committee, 1977. They came and stayed. Rosebud County History. Western Printing and Lithography, Billings, Montana.

Rosebud County Planning Board, 1979. Planning data book and comprehensive plan, Rosebud County, Montana.

_____, 1980. Rosebud County plan, 1980 update.

Rugemer, Vince, 1982. President, Security Bank of Colstrip, Colstrip, Montana. Personal communication, June 3.

Sandoval, F.M. et al., 1973. Lignite mine spoils in the Northern Great Plains -- characteristics and potential for reclamation, in Research Microbial Activity of 1- to 50-year-old strip-mine spoils. Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana. 209 p.

References (Continued)

Schafer, W.M., 1979. Guides for estimating cover-soil quality and mine soil capability for use in coal stripmine reclamation in the Western United States. Reclamation Review Vol. 2, pp. 67-74, Pergamon Press, Ltd.

Schafer, W.M. et al., 1977. Soil genesis, hydrological properties, and root characteristics of 2- to 53-year-old strip-mine spoils. Report No. 108. Montana Agricultural Experiment Station, Bozeman, Montana.

Schafer, W.M., G.A. Nielson, and W.D. Nettle, 1979a. Morphology of a paralithic contact in a soil over soft sandstone. Soil Science Society of America Journal, Vol. 43, March-April 1979, pp. 383-386.

Schafer, W.M., Nielson, G.A., Dollhopf, G.A., and K. Temple, 1979b. Soil genesis, hydrological properties, root charactertistics, and microbial activity of 1- to 50-year-old strip-mine spoils. Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana. 209 p.

Schmidt, J., and M.K. Botz, 1978. Mining and mineral fuels development in the Montana statewide 208 study area: Implications to water quality. Final Draft. Department of Health and Environmental Sciences.

Schuman, G.E. et al., 1980. Standing stubble versus crumped straw mulch for establishing grass on mined lands. Journal of Soil and Water Conservation, Jan.-Feb. 1980. Vol. 35, No. 1.

Schumm, S.A., 1961. The effect of sediment characteristics on erosion and deposition in ephemeral stream channels. USGS Prof. Paper 352C, pp. 31-70.

_____, 1973. Geomorphic thresholds and the complex response of drainage systems, in Fluvial Geomorophology. Morisawa, M. (ed.). State University of New York, Binghampton, pp. 299-310.

_____, 1977. The fluvial system. New York: John Wiley & Sons. 338 p. Schumm, S.A., and Lichty, 1965. Time, space, and causality in geomorphology. American Journal of Science (263), pp. 110-119.

Schwind, D.R., and N.D. Krause, 1978. Community noise measurements: Colstrip job 12288-007. Bechtel National, Inc.

Schye, Elsie, 1982. District Clerk, School District #19, Colstrip, Montana. Personal communication, February 12.

Seghetti, L. 1951. Correspondence to the project engineer from Montana State College, Agriculatural Experiment Station, Bozeman, Montana (Aug. 15). Referenced in Water Quality Criteria, Publications 3-A, California State Water Resources Control Board, Sacramento, California, p. 113.

References (Continued)

Sherfy, Marcella, 1982. Montana State Historic Preservation Office, Helena, Montana. Personal communication, January 11, January 12, January 19, January 21.

Shown, L.M., 1970. Evaluation of a method of estimating sediment yield. USGS Prof. Paper 700-B, pp. 274-277.

Sinnott, Don, 1982. Architect, Helena, Montana. Personal communication, July 29.

Skaar, Palmer, S., 1975. Montana bird distribution preliminary mapping by latilong. Skaar, Bozeman, Montana.

Slagle, S.E. , and J.R. Stimson, 1979. Hydrogeologic data from the northern Powder River Basin, southeastern Montana. USGS Open-File Report 79-1332. 115 p.

Smith, R.M. et al., 1974. Mine spoil potentials for soil and water quality: Environmental Protection Technology Series, EPA-670/2-74-070, National Environmental Research Center, Cincinnati, Ohio. 303 p.

_____, 1976. Extensive overburden potentials for soil and water quality. Environmental Protection Technology Series, EPA 600/2-76-184, National Environmental Research Center, Cincinnati, Ohio.

Smith, Verne E., 1976. The application of HYMO to study areas of southwestern Wyoming for surface runoff and soil loss estimates. Water Resource Series No. 60, Water Resources Institute, Laramie, Wyoming.

Smythe, Ted, 1982. Department of Generation and Dams Engineering, Montana Power Company, Butte, Montana. Personal communication, January 13.

Soil Survey Staff, 1975. Soil taxonomy - a basic system of soil classification for making and interpreting soil surveys. U.S. Department of Agriculture, Soil Conservation Service. Agricultural Handbook No. 436. 754 p.

Spear, Michael, 1980. Federal coal management (leasing) program-unsuitability criterion - 14 guidelines. U.S . Fish and Wildlife Service and Bureau of Land Management. U.S. Fish and Wildlife Service instructional memorandum, May 12.

Spiegel, Mickey, 1982. Wirth and Associates, Billings, Montana. Personal communication, February 4.

Stanhill, G.A., 1961. A comparison of methods of calculating potential evapotranspiration from climatic data. Israel Journal of Agricultural Research 11:3-4, pp. 159-171.

References (Continued)

Stark, N., 1980. The soils and ecology of establishing conifers on spoils at Colstrip. Program report submitted to Western Energy Company, Dec. 31, 1980. 104 p.

_____, 1982. Ponderosa pine establishment on strip mined lands. Presented at Reclamation Symposium, March 8, 1982 sponsored by the Bureau of Land Management and Montana State University, Bozeman, Montana.

Stebbins, R.C., 1966. A field guide to western reptiles and amphibians. Boston: Houghton Mifflin.

Steere, L., 1980. Preliminary excavations of the Sly Bison site. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

_____, 1982. Cultural resources inventory and assessment: Western Energy Mining Area C, Blocks I and II. Cultural Resources Division, Mineral Research Center, Montana Tech Alumni Foundation, Butte.

Steere, Pete, 1982. Montana Tech Alumni Foundation, Butte, Montana. Personal communication, January 20.

Stiller, D.M., Zimpfer, G.L., and M. Bishop, 1980. Applications of geomorphic principles of surface mine reclamation in the semi-arid West. Jul. Soil Water Cons. (35), pp. 274-277.

Stoner, J.D., 1981. Horizontal anisotropy determined by pumping in two Powder River Basin coal aquifers, Montana. U.S. Geological Survey, Pittsburgh, Pennsylvania, pp. 34-40.

Stoner, J.D., and B.D. Lewis, 1980. Hydrogeology of the Fort Union coal region, eastern Montana. USGS Miscellaneous Investigations Map I-1236, 2 sheets.

Stout, B. 1980. Studies of tree root systems at Colstrip, Montana. Symposium of Soil Conservation Society of America and Western Agricultural Experiment Stations, March 26-27, Billings, Montana.

Strahler, A.M., 1957. Quantitative analysis of watershed geomorphology. Trans. Amer. Geophys. Union (38), pp. 913-920.

Systems Technology, Inc., 1983. Potential water use effects of estimated spoils related increases in total dissolved solids of the Rosebud Mine Area. DSL open file report.

Taylor, D.W., 1975. Early Tertiary mollusks from the Powder River Basin, Wyoming-Montana, and adjacent regions. USGS Open-File Report 75-331.

Taylor, Ryan, 1982. Superintendent, Forsyth School District #4, Forsyth, Montana. Personal communication, September 6, 1982.

References (Continued)

Thiessen, Bob, 1982. President, First State Bank of Forsyth, Forsyth, Montana. Personal communication, June 6.

Thornes, J.B., 1980. Channel changes inephemeral streams: Observation problems and models. Ch. 21, in River Channel Changes. Gregory, K.J. (ed.) John Wiley & Sons, New York. pp. 317-335.

Tokerud, Harold, 1982. Superintendent of Schools, District #19, Colstrip, Montana. Personal communication, January 16.

Tomasik, Jack, 1982. Mountain West Research, Inc., Billings, Montana. Personal communication, February 4.

Torrey, S. (ed.), 1978. Trace contaminants from coal. Pollution Technology Review (50). Noyes Data Corporation, Park Ridge, N.J. 294 p.

TRC Environmental Consultants, Inc., 1981. Coal mining - emission factor development and modeling - study. TRC Project No. 0908-Div-05.

Tusler, Melinda, 1982. Rosebud County Sanitarian, Forsyth, Montana. Personal communication, January 18.

Tyus, H.M. and J.M. Lockhart, 1979. Mitigation and research needs for wildlife on western surface mined lands in The Mitigation Symposium: A national workshop on mitigating losses of fish and wildlife habitats. Swanson, G.A. (ed.).

Udvardy, M.D.F., 1977. The Audubon Society field guide to North American birds, western region. New York: Alfred A. Knopf.

Upper Midwest Council, 1982. Upper Midwest Retail Trade Centers, Minneapolis, Minnesota.

U.S. Bureau of the Census, 1979. Projections of the number of households and families, 1979-1995. Population Estimates and Projections, Series P-25, No. 805, Washington, D.C.

U.S. Bureau of the Census, 1979. 1977 Census of Retail Trade: Montana, U.S. Department of Commerce, Washington, D.C.

_____, 1981. 1980 census of population and housing. Advance reports. Montana Department of Administration, Helena, Montana.

U.S. Bureau of Economic Analysis, 1981. 1980 OBERS BEA regional projections. U.S. Government Printing Office, Washington, D.C. Seven volumes.

U.S. Bureau of Economic Analysis, Annual Data: Regional economic information system. Unpublished, Department of Commerce, Washington D.C.

U.S. Department of Agriculture, 1954. Agricultural Handbook 60, Diagnosis and Improvement of Saline and Alkali Soils.

References (Continued)

U.S. Department of Agriculture, Soil Conservation Service, 1976. National Range Handbook.

_____, 1981. Technical range site descriptions for eastern sedimentary plains, 10-14 inch precipitation zone. Montana Technical Guide, Section II-8.

U.S. Department of Agriculture, Soil Conservation Service and State of Montana, 1979. The Montana Soil Conservation Service Technical Guide, Section II-E-8.

U.S. Department of the Interior, 1977. Resource and potential reclamation evaluation - Bear Creek study area, West Moorhead coalfield. EMRIA Report #8. 148 p., appendices.

_____, 1978. Proposed development of coal resources in the eastern Powder River Basin of Wyoming, Draft environmental impact statement.

_____, 1978. Draft, environmental impact statement on proposed expansion of Peabody's Big Sky Mine, Rosebud County, Montana: DES 78-51, prep. by USGS and Montana DSL. 238 p.

_____, 1979. Final environmental impact statement on proposed expansion of Peabody's Big Sky Mine in Rosebud County, Montana: Federal Lease M-15965, prep. by USGS and Montana DSL. 293 p.

_____, 1979. Draft environmental impact statement on regional analysis of Northern Powder River Basin coal, Montana: Prep. by USGS and Montana DSL. 293 p.

U.S. Department of the Interior, Bureau of Land Management, 1981. Powder River regional coal - final environmental impact statement. Bureau of Land Management, Casper, Wyoming.

U.S. Department of the Interior, Geological Survey, 1972. Recommended methods for water-data acquisition. (Preliminary Report of Federal Interagency Work Group on Design of Standards for Water-Data Acquisition, impaneled by U.S. Geological Survey Office of Water-Data Coordination). USGS, Washington, D.C.

_____, 1981. Methodology for hydrologic evaluation of a potential surface mine: East Trail Creek Basin; Big Horn County, Montana. R. F. Hadley, D. G. Frickel, L.M. Shown, and R.F. Miller. USGS Water Resources Investigations, Open-File Report 81-58.

_____, 1974. Final impact statement for proposed plan of mining and reclamation, Big Sky Mine, Peabody Coal Company, Federal Lease M-15965. Colstrip, Montana (FES 74-12).

_____, 1976. East Decker and North Extension Mines, Decker Coal Company, Big Horn County, Montana. Vol. I, DES.

References (Continued)

_____, 1979. Final proposed Colstrip project environmental statement. Rosebud County, Montana (FES 79-29). 900 p.

_____, 1979. Proposed mining and reclamation plan, Pearl Mine, Big Horn County, Montana, Vol. I, DES.

_____, 1979. Proposed mining and reclamation plan. Spring Creek Mine, Spring Creek Coal Company, Big Horn County, Montana. FES.

_____, 1980. Proposed mining and reclamation plan, Pearl Mine, Big Horn County, Montana. FES.

U.S. Department of the Interior, Bureau of Land Management, (No date). Draft environmental impact statement: Proposed Colstrip Project, Rosebud County, Montana, Sections 2.1 and 2.2, pp. 2.1-1 to 2.1-9.

U.S. Department of the Interior, Geological Survey, and Bonneville Power Authority, 1979. Colstrip Project Environmental Impact Statement.

U.S. Department of the Interior and Montana Department of State Lands, 1979. Final environmental statement for the proposed expansion of mining and reclamation plan, Big Sky Mine, Peabody Coal Company, Rosebud County, Montana, Federal Lease M-15965 (FES 79@46). 129 p.

U.S. Department of the Interior and Montana Department of State Lands, 1980. Final environmental statement, regional analysis, northern Powder River basin coal, Montana (FES 80-1). Two volumes.

U.S. Environmental Protection Agency, 1971. Noise from construction equipment and operations, building equipment, and home appliances, NTID 300.1.

_____, 1973, Water quality criteria 1972. Environmental Protection Agency RE-033. 594 p.

_____, 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. EPA Bulletin 550/9-74-004.

_____, 1974. Manual of methods of chemical analysis of water and wastes. U.S. Environmental Protection Agency, Office of Technology Transfer, Washington, D.C.

_____, 1975. Guidelines for air quality maintenance planning and analysis, Vol. 7: Projecting county emissions. 2nd ed. USEPA, Research Triangle Park, North Carolina, Publ. No EPA-450/4-74-008. 186 p.

_____, 1975. National interim primary drinking water standards. Federal Register (FRL 464-7) Vol. 40, No. 248, December 24, 1975, pp. 59566-59588.

References (Continued)

_____, 1977. Compilation of air pollutant emission factors. 3rd ed. (including supplements 1-7). EPA-OAQPS, Research Triangle Park, North Carolina, Publ. No. EAP-42, August.

_____, 1977. Preliminary guidance for estimating erosion in areas disturbed by surface mining activities in the interior western United States. EPA-908/4-77-005.

_____, 1978. Supplement No. 8 for compilation of air pollutant emission factors. 3rd ed. EPA-OAQPS, Research Triangle Park, North Carolina, Publ. No. AP-42, Suppl. 9, May.

_____, 1979. Supplement No. 9 for compilation of air pollutant emission factors. 3rd ed. EPA OAQPS, Research Triangle Park, North Carolina, Publ. No. AP-42, Suppl. 9, April.

U.S. Environmental Protection Agency, 1979. Conditional permit to commence construction and operate Units #3 and #4. Issued by EPA Region VIII, Denver, Colorado, Sept. 11, 1979.

U.S. Public Health Services, 1962. Drinking water standards. Rev., 1962. U.S. Public Health Service Publ. 956. 61 p.

U.S. Salinity Laboratory Staff, 1954. Diagnosis and improvement of saline and alkali soils. U.S. Dept. of Agriculture Handbook 60, pp. 83-126.

Van Voast, W.A., and R.B. Hedges, 1974. Hydrology of the area of Westmoreland Resources Tract-3 coal reserves near Sarpy Creek, southeastern Montana. Montana Bureau of Mines and Geology Open-File Report, Butte, Billings, Montana.

_____, 1974. Hydrology of Western Energy Company's probable mine areas near Colstrip, southeastern Montana. Montana Bureau of Mines and Geology Open-File Report. 31 p.

_____, 1977. Hydrogeologic conditions and projections related to mining near Colstrip, southeastern Montana. Montana Bureau of Mines and Geology Bulletin 102, Butte, Billings, Montana.

_____, 1978. Strip coal mining and mined land reclamation in the hydrologic system, southeastern Montana. Montana Bureau of Mines & Geology.

Van Voast, W.A., R.B. Hedges, and J.J. McDermott, 1976. Hydrologic aspects of strip mining in the subbituminous coal fields of Montana, in Fourth Symposium on Surface Mining and Reclamation Proceedings, Louisville, Kentucky. National Coal Assoc., Washington, D.C., pp. 160-172.

_____, 1978. Strip coal mining and mined-land reclamation in the hydrologic system, southeastern Montana, project completion report: Old West Regional Commission Grant No. 10570165. 122 p.

References (Continued)

_____, 1978. Groundwater of the Fort Union coal region, eastern Montana. Montana Bureau of Mines and Geology Special Publication 80.

Viall, Jeanette, 1982. Southeastern Montana Rural Health Initiative Program, Miles City, Montana. Personal communication, February 4.

Vlek, P.L.G., and W.L. Lindsay, 1977. Molybdenum contamination in Colorado pasture soils in Molybdenum in the environment. W.R. Chappell and K.K. Peterson (eds.) Marcel Decker, Inc., New York. Vol. 2, pp. 619-650.

Wallace, J.M., and P.V. Hobbs, 1977. Atmospheric science, an introductory survey. Academic Press, New York.

Wallmo, O.C. and W.L. Regelin, 1981. Rocky Mountain and intermountain habitats, Part I: food habits and nutrition in Mule and Blacktailed Deer of North America. O.C. Wallmo (ed.) University of Nebraska Press, Lincoln, Nebraska. 605 p.

Wells, S.G., 1978. Geomorphology and surface hydrology in the strippable coal belts of northwestern New Mexico. Unpubl. report: New Mexico Energy and Minerals Dept. 68 p.

Westech, 1979. Western Energy Company alluvial valley floor assessment: mining area "B" draft report. 31 p.

Western Analysis, Inc., 1982. Socioeconomic Technical Report: Western Energy Company Area C Mine Expansion. Helena, Montana.

Western Energy Company, January 9, 1981. Application for amendment to Surface Mining Permit #80003, Area B; Section 7, 8, 17 and 18, T1N R41E, and Sections 12 and 13, T1N R40E (on file at the Department of State Lands, Helena, Montana).

Western Energy Company, 1978. Vegetation resource reports, 3 volumes.

Western Energy Company's Comprehensive Mine Plan, Rosebud Mine, Colstrip Montana Mine Areas A, B, C, D, E and Pit 6, Volume I-V, July 1981.

_____, 1978. Permit application submitted to Montana Department of State Lands (on file).

_____, 1980. Vegetation resource reports, 3 volumes.

_____, 1980. Annual wildlife report. Rosebud Mine, Colstrip, Montana.

_____, 1980. Letter from Western Energy Company to Montana Air Quality Bureau.

_____, 1981. Application for a surface mining permit, Area C, Block I.

_____, 1981. Air quality program, Rosebud Mine, Colstrip, Montana. Vols. I and II. Submitted to Montana DSL, Helena, Montana.

References (Continued)

Western Historical Publishing, 1907. An illustrated history of Yellowstone Valley embracing the counties of Park, Sweet Grass, Carbon, Yellowstone, Rosebud, Custer, and Dawson. Spokane, Washington, pp. 319-328.

Westinghouse Electric Corporation, 1973. Colstrip generation and transmission project, applicant's environmental analysis. Westinghouse Electric Corporation, Environmental Systems Dept., Pittsburgh, Pennsylvania, Sec. 2.2.2.6.1.

Wetstein, Willis, 1982. Morrison-Maierle, Inc., Helena, Montana. Personnel communication, July 28.

Whitaker, J.O., 1980. The Audubon Society field guide to North American mammals. New York: Alfred A. Knopf.

Williams, John, 1982. Manager of Administration, Montana Power Company, Colstrip, Montana. Personal communication, February 23.

Williams, J.R., and H.D. Berndt, 1976. Determining the universal soil loss equations length-slope factor for watersheds, in Soil Erosion: Prediction and Control. Soil Conservation Society of America, Special Publication No. 21.

Williams, J.R., and R.W. Hann, 1973. HYMO: Problem-oriented computer language for hydrologic modeling, user's manual. USDA, Agricultural Research Service, ARS-S-9.

Wind, G.P. 1961. Capillary rise and some applications of the theory of moisture movement in unsaturated soils. Institute for Land and Water Management Research Technology, Bulletin 22.

Wirth/CSSA Joint Venture and Mountain West Research, Inc., 1982. Colstrip Area Market Study prepared for the Montana Power Company, Billings, Montana.

Wischmeier, W.H., 1976. Use and misuse of the universal soil loss equation. Journal of Soil and Water Conservation 31 (1):5-9.

Wischmeier, W.H., and D.P. Smith, 1978. Predicting rainfall erosion losses: A guide to conservation planning. U.S. Department of Agriculture, Agricultural Handbook #537.

Woodmansee, R.G., J.D. Reeder, and W.A. Berg, 1978. Nitrogen in drastically disturbed lands in forest soils and land use in Proceedings of the Fifth North American Forest Soils Conference, Colorado State University, Fort Collins, Colorado.

Workman, Rob, 1982. Real Estate Coordinator, Western Energy Company, Colstrip, Montana. Personal communication, February 8.

Wright, H.E., Jr., and D.G. Frey (eds.), 1965. The Quaternary of the United States. International Association of Quaternary Research, 7th Congr., Princeton University Press, Princeton, N.J. 922 p.

References (Continued)

Wyoming Department of Environmental Quality, 1979. Memorandum on fugitive dust emission factors. Cheyenne, Wyoming, January 24.

Printing and distribution costs were paid by Western Energy Company pursuant to Title 75, Chapter 1, Part 2 MCA.